Report: 77-1
Date: January, 1977

NP--24221

MASTER

Send Back EDA application
To: Harold Derrah
City Hall
Klamath Falls, Ore.
97601

GEO-HEAT UTILIZATION CENTER

KLAMATH COUNTY GEO-HEATING DISTRICT FEASIBILITY STUDY

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

KLAMATH COUNTY GEO-HEATING DISTRICT

FEASIBILITY STUDY

for

Klamath County Commissioners
Klamath County Courthouse
Klamath Falls, Oregon

by

Paul J. Lienau
John W. Lund
G. Gene Culver

Geo-Heat Utilization Center
Oregon Institute of Technology
Klamath Falls, Oregon 97601

January, 1977

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to:

The Klamath County Commissioners for their encouragement to undertake this project.

Mr. Earl Kessler for guidance and direction of this project.

Invaluable field assistance, drafting and analysis was provided from students Stephen Doyle, Douglas Ford and Alan Rathmacher and many others who freely gave of their time during the pump test.

Numerous manufacturers provided information on their products. Their assistance is gratefully acknowledged.

Finally, we are deeply appreciative to Kathy Green for long hours on typing the report.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

I. Summary

This report is the result of an agreement between the Klamath County Commissioners and Oregon Institute of Technology Geo-Heat Utilization Center for the conceptual design, cost analysis and plan for space heating a number of public buildings in Klamath Falls, Oregon with geothermal hot water. The report is to assist Klamath County and the city of Klamath Falls in implementation of the plan for funding the project through appropriate agencies. This project was principally aimed at supplying geothermal heat to ten city and county buildings by hot water extracted from the existing museum well. The supply system is also designed to include the post office and a new building to be built in the vicinity of the courthouse. The fluid would be piped from the museum well to three liquid-to-liquid heat exchangers and returned to the area of the producing well for reinjection into the same aquifer.

The study also considered space heating of 98 additional buildings in the downtown business district equivalent to the ten public buildings and incorporating a snow removal grid on Main Street between Eleventh and Fourth Streets. The geothermal fluid would be supplied from wells in the vicinity of Old Fort Road (city police pistol range) and returned for reinjection.

Based on the study, the Center has concluded that no major resource or engineering difficulties exist that would prevent the ten-building project from being completed successfully with a significant long-term savings in both scarce fossil fuels and total heating costs. A direct environmental benefit of the large-scale plan would be a significant reduction in air pollutants (16 tons per year) from the burning of natural gas.

For a capital investment of approximately $548,900 the delivery system, conversion of building heating systems and waste disposal could be accomplished for the ten buildings with potential expansion to twelve. On an annual basis, operation, maintenance repair and interest on a 25-year retirement would be $54,240 per year. This compares with an estimated 1976 annual natural gas heating cost of $69,300 or fuel oil heating cost of $94,900. As an added benefit, a geothermal system insures against increasing scarcity and escalating costs of fossil fuels.

If the 12-building plan were fully implemented, it will:

1. Provide heat equivalent to approximately 159 average homes;

2. Save 275,900 therms (27.6 million ft^3) of natural gas, or 207,000 gallons of fuel oil per year;

3. Provide the equivalent capacity of a 4.1 MW electric power plant.

If the 110-building plan were fully implemented, it will:

1. Provide heat equivalent to approximately 1,140 average homes;

2. Save 1,970,000 therms (197 million ft^3) of natural gas or 1,478,000 gallons of fuel oil per year;

3. Provide the equivalent capacity of a 29.3 MW electric power plant.

It is recommended the county and city proceed with the proposed project. Full implementation of the 12-building base plan would provide year-around heat at less than 78% of current fossil fuel heating costs.

TABLE OF CONTENTS

I. Summary ii
II. Background 2
III. Objectives 2
IV. Extraction and Fluid Disposal 3
A. Museum Well 3
B. Reinjection 8
C. Other Production Well Locations 9
V. Climate Factors 9
VI. Delivery System 10
A. Introduction 10
B. Routes 14
C. Piping and Insulation 14
D. Size of Pipeline, Flow Characteristics and Insulation Requirements 19
E. Power Required by Pumps 21
F. Controls for Heat Supply System 23
G. Materials of Construction 23
VII. Building Conversion to Geothermal (Retrofit) 28
A. General Design Considerations for Establishing the Building Peak Heating Load 28
B. General Retrofit Considerations 28
C. Controls 30
D. Klamath County Museum Conversion 36
E Central Fire Station Conversion 39
F. City Hall Conversion 43
G. City Police Station Conversion 45
H. Klamath County Courthouse Conversion 49
I. Veterans Memorial Building Conversion 54
J. Klamath County Jail Conversion 58
K. Klamath County Library Conversion 62
L. Klamath County Courthouse Annex Conversion 66
VIII. Economics 69
IX. Environmental Considerations 75
A. Fluid Extraction-Reservoir Effects 75
B. Energy Conversion 77
C. Waste Disposal 77
X. References 80
XI. Appendix
A. Study Proposal 81
B. Product Directory and Estimating Prices 88
C. Museum Well Pump Test 113
XII. List of Figures
1. Museum Well Pump Test and Observation Wells 5
2. Drawdown Curves for Museum Well Pump Test 6
3. Museum Well Drawdown 7
4. Yearly Temperature Distribution in Klamath Falls 11
5. Klamath Falls Monthly Mean Temperature 12

6. Klamath Falls Monthly Degree Heating Days 12
7. Estimates on Monthly Therm and Gallon Requirements 13
8. Distribution System 15-17
9. Controls for Heat Supply Systems 24
10. Well Water Chemistry 26-27
11. Control Diagram 32
12. Control Component Key 33
13. Courthouse Boiler Connections 34
14. Key to Drawing Symbols 35
15. Cost Comparisons for Three Project Sizes and Natural Gas 76

XIII. List of Tables

1. Comparison of Hot-Water Pipelines 19
2. Pipeline Data Sheet 22
3. Building Data Sheet 29
4. Cost Comparisons 70
4a. Geothermal Well Options 71
4b. Approximate Cost of Underground Pipe 72
5. Building Conversion Costs 73
6. Energy Utilization and Savings 74

CONVERSIONS

This report was written based on English units. The following conversion table gives the SI unit conversions.

1 mi	= 1.609 Km (Kilometer)	
1 ft	= 0.3048 m (meter)	
1 ft^2	= 9.290×10^{-2} m^2 (square meter)	
1 ft^3	= 2.832×10^{-7} m^3 (cubic meter)	
1 lb	= 4.448 N (Newton)	
1 ft/s	= 0.3048 m/s (meter/sec)	
1 psi	= 6895 P (pascal)	
1 BTU	= 0.2520 C (Kilocalories)	
1°F	= 9/5°C + 32	

II. BACKGROUND

Geothermal space heating has received considerable interest recently due to the increased cost and potential shortages of other types of fuel. Space heating of the type often practiced in Klamath Falls (one well - one house concept) is generally not economical due to the high initial cost of drilling and casing the well (Lund, et al., 1974). Space heating on a large scale, or district heating, has proven to be a more practical and an economical alternative as demonstrated in Iceland and Hungary and to a minor degree in New Zealand (Zoega, 1974; Boldizar, 1974; and Burrows, 1974).

Geothermal district heating exists in the United States with heating of 175 homes along Warm Springs Avenue in Boise, Idaho, being the most notable example (Schmitt, et al., 1976). Klamath Falls offers an ideal situation to study and evaluate geothermal heating in order to optimize the use of a single, or several wells to heat a number of individual homes and/or larger structures. The passing of House Bill 3185 in Oregon during the 1975 regular session, authorizing the formation of geothermal heating districts, added impetus to this study.

The Klamath County Commissioners contacted the Geo-Heat Utilization Center to undertake a feasibility study for converting county and city public buildings to geothermal heat. They envisioned using the existing county museum well to supply the energy to the ten public buildings.

We proposed to study the extraction of geothermal fluids from the museum well by means of a pump test to determine potential and effect on neighboring wells and make recommendations on a delivery system, building conversion, fluid disposal and estimated geo-heating cost effectiveness compared to conventional seasonal heating costs.

III. OBJECTIVES

The objective of the study was to determine the most economical system that would provide the required amount of energy for heating public buildings in Klamath Falls, Oregon. Specific objectives were:

1. Pumping the existing museum well to determine its potential, characteristics and effect on nearby wells.

2. Determine the amount of energy required through climate analysis and building heat load requirements to heat the public buildings.

3. Determine the most economical design for transporting the energy from the well to the buildings.

4. Determine geothermal retrofit requirements and estimated costs to convert each building from conventional heating methods to geothermal.

5. Determine options for disposal of the geothermal fluid.

6. Determine estimated cost effectiveness of the geothermal heating system capitalization, operation and maintenance, compared to conventional heating costs.

IV. EXTRACTION AND FLUID DISPOSAL

A. Museum Well

The main reason for undertaking this study is that the majority of the public buildings (except the museum and fire station) are not located within the geothermal well area in Klamath Falls. Based on meager information and some data from shallow "cold" water wells (<100°F), the possibility of drilling for hot water at reasonable costs and depths in the downtown core area is felt to be marginal and risky. The recent drilling (1975) of the successful 1235 foot deep county museum geothermal well was felt to provide a potential hot water supply for heating the eight public buildings in the downtown core.

In an attempt to test the potential of the museum well for providing the necessary energy (hot water), a pump test was undertaken during August of 1976. In addition to measuring the production of this well, observation wells were monitored to measure the water level and temperature changes in the surrounding area. The location of these wells is shown on Figure 1.

Due to uncertainty in the museum well production rate and effects of caving, surging, etc., the pump test was performed in three stages of increasing pumping rate. These are summarized as follows.

Average Rate gpm±	Length of Time hrs	Drawdown Below Casing Top ft*	Average Temperature °F
320	2	4	184
470	2	11	180
670	24	27	184

*Estimated to have up to a 2-foot artesian head, which is not included in these figures.

The maximum drawdown in the observation wells during the 670 gpm pumping rate is as follows.

Well	Distance from Museum Well ft.	Maximum Drawdown in.
KU-1	1070	13
KU-2	1305	15
FS-3	129	46
LJ-4	1087	13
MW-5	924	10
CS-6	123	11
HD-7	810	18-1/2
CP-8	283	--
GC-9	640	21
EB-10	758	9*
EA-11	1105	2
TX-12	1425	4

*Estimated to have up to a 2-foot artesian head, which is not included in these figures.

Since the 670 gpm pumping rate is approximately the maximum rate needed to supply heating for the ten public buildings, the effect of this rate is important. Figures 1 and 2 are the drawdown diagram and contour map of the area surrounding the museum well and indicate the approximate zone of influence of the 670 gpm pumping rate. The details of the pump test are given in Appendix C.

The entire pump test took place over only a 28-hour time span, thus it is difficult to predict the long-term effect of this pumping rate on the reservoir. It is estimated by others (Sammel, 1976) that the reservior has high vertical and horizontal permeability with circulation to depths of 14,000 feet. For this reason we believe that the 28-hour test is probably a fairly good indication of the long-term effects. The pumping of the museum well will undoubtedly have some effect on adjacent wells, both artesian and non-artesian. However, it is felt that weather problems, especially rain fall and snow melt, have a stronger effect on water levels in the area. Already during the winter of 1976-77, which was preceded by an extremely dry fall, many wells have had a significant water level drop. Other wells in the geothermal area are experiencing similar drops in water level. This appears to be typical of the winter period in Klamath Falls. In addition, increased pumping by 45 other well owners in the urban area appears to have some influence on the water level; however, it is difficult to quantify this influence. Based on the pump test at the museum well and a 1974 test at OIT, the horizontal influence appears to be limited, with the one-foot or greater drop being less than 500 feet from the production well in the E-W direction and 2,000 feet in the N-S direction.

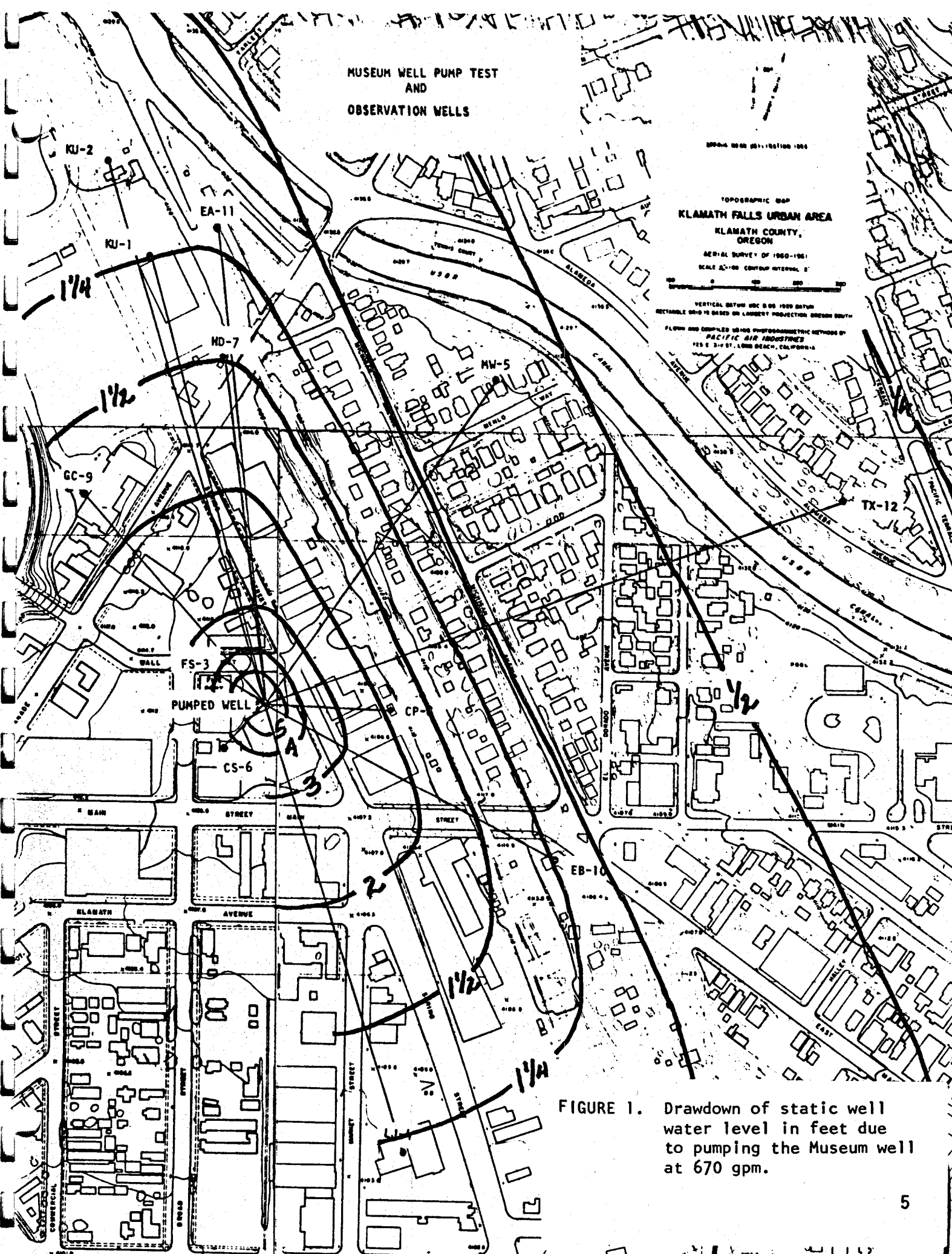


FIGURE 1. Drawdown of static well water level in feet due to pumping the Museum well at 670 gpm.

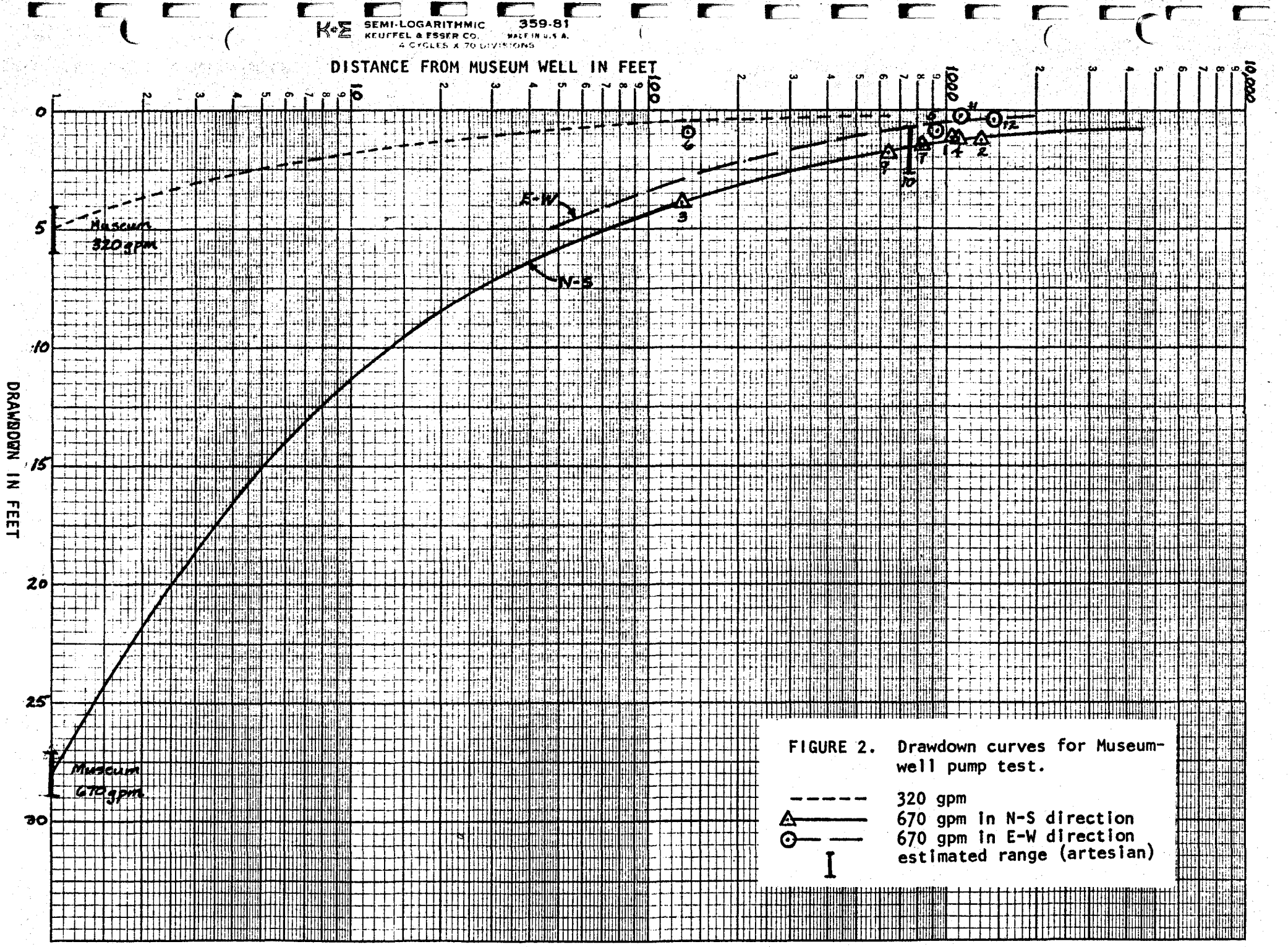
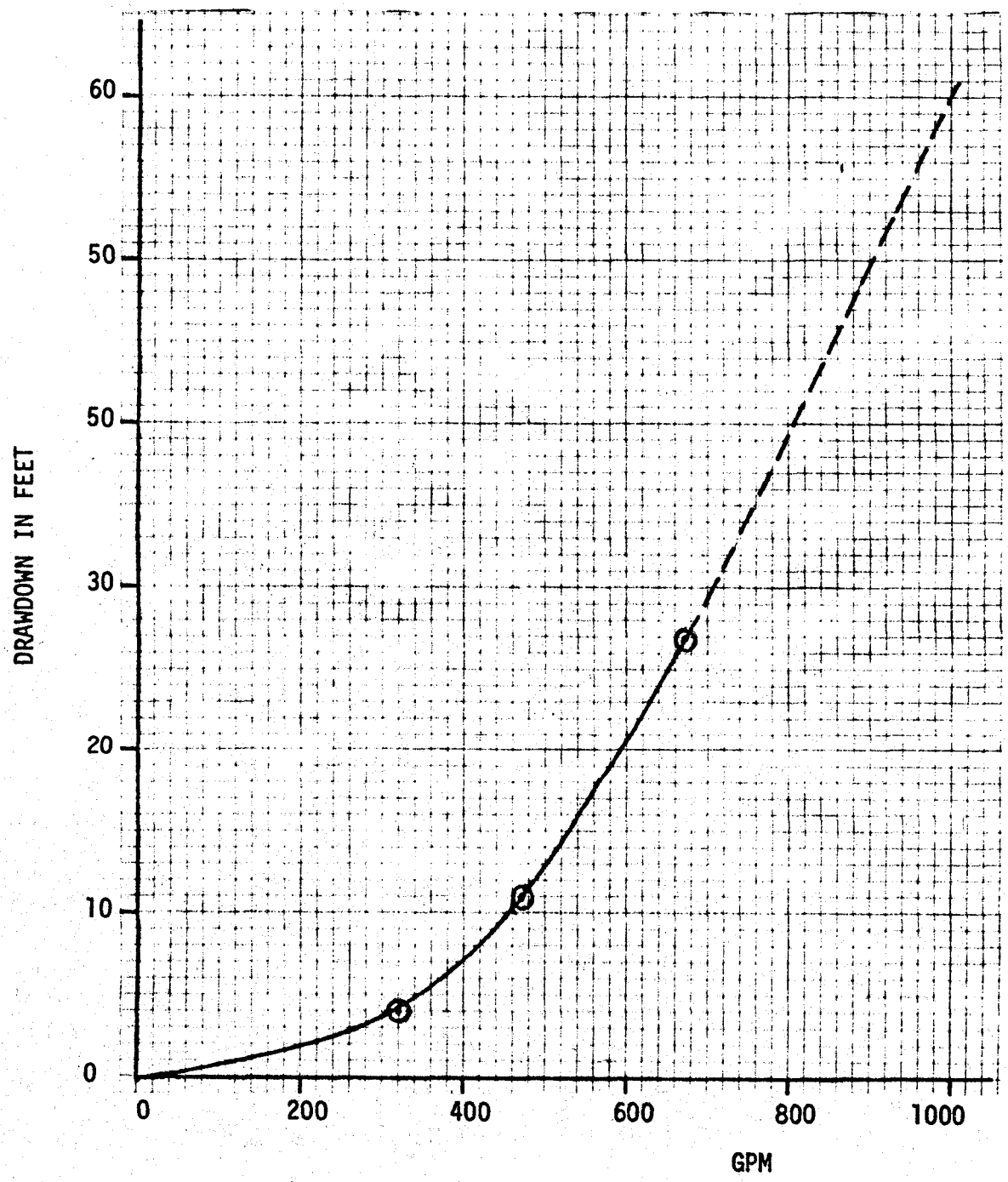


FIGURE 2. Drawdown curves for Museum-well pump test.

- - - - - 320 gpm
△——— 670 gpm in N-S direction
⊙— — 670 gpm in E-W direction
I estimated range (artesian)

FIGURE 3

DRAWDOWN VS PUMPING RATE
FOR THE COUNTY MUSEUM WELL



During the course of the pump test, several reports were made concerning the "killing" of artesian wells in the vicinity of the museum well. What happened was that the artesian pressure had been effected slightly in these wells causing the head to drop from approximately two feet above the casing top to one foot below. This problem can be corrected by pumping.

Extending the results of the pump test to higher pumping rates would increase the drawdown in the museum wells. Figure 3 indicates the approximate relationship, with a 1000 gpm pumping rate, producing at least a 60-foot drawdown. This in turn would effect the surrounding wells, extending the influence to a greater horizontal distance. These higher pumping rates are not recommended due to this influence.

B. Reinjection

The obvious counter measure to prevent excessive drawdown is to reinject the pumped fluid back into the aquifer. If this is attempted, it is recommended that the reinjection well be at least 300 feet from the production well, so as to minimize the effect on the temperature of the latter. Two successful uses of reinjection wells are known in the Klamath Falls area, that of Mazama Mid High and Klamath Union High School. Both of the pairs of wells are approximately 300 feet apart and appear to function satisfactorily under a gravity reinjection system. Reinjection would tend to minimize the depletion of the reservoir fluid and is recommended for future planning and conservation.

Two possible locations for the reinjection well can be considered. The first would be adjacent to the downtown core area. The location would eliminate the need for a return line; however, the reinjected warm water would probably influence cold water wells in the area and not contribute to recharging the hot water aquifers. Returning the warm water and reinjecting it near the supply well appears to be the most realistic solution. This alternative would require a return line; however, since the supply line trench would already be constructed, the only cost would be for the uninsulated pipe. The reinjected fluid would then have a good potential for recharging the production aquifer. A location near the corner of Klamath Avenue and Broad Street is recommended (see Figure 1). See page 75, Waste Disposal, for additional discussion on reinjection.

The city fire station well was also considered as a possible reinjection well for the entire system, but was rejected due to the close proximity to the supply well and questionable well completion practices during the original drilling. It is recommended that it be only used as the reinjection well for the geothermal water from the museum and fire station. This latter quantity is only 182 gpm at maximum use. This would save providing a return line to the main reinjection well.

C. Other Production Well Locations

In the event that the use of the museum well is unacceptable or that additional flow is required for an expanded heating system, other production well locations should be considered. Since additional flow and/or less influence on adjacent wells would probably be the reason for an alternate site, a location away from the normal well area is desired. An area that meets these requirements and has a good potential for producing hot water is in the Old Fort Road area near the county dump and city pistol range. Public property is available here, is located away from the normal well area, and can provide a gravity flow system due to its higher elevation. The area is located near the fault system that is noted for producing "good" hot water wells.

Several wells could be located in this area with the potential for each producing up to 500 gpm. They would probably be required to be drilled to at least 1500 feet in depth and would cost $45,000 each. A supply line would have to be constructed following Old Fort Road and Main Street, crossing the "A" Canal near the Main Street bridge.

Reinjection could be undertaken either near the production well site or near the museum well site. Either site is acceptable as they are both in the known hot water area and the subsurface water flow (hydraulic gradient) is in the westerly to southwesterly direction; thus the reinjected water would probably recharge the producing aquifer.

The spacing of these wells should be well planned and far enough apart so as not to influence each other. A recommended spacing of at least 3000 feet for production and reinjection wells is recommended, and 1000 feet between production wells. The exact spacing would be based on a more detailed analysis of the specific site and pumping tests of the first two or three wells.

V. CLIMATE FACTORS

The objective of space heating or cooling is to maintain a constant optimum temperature inside the buildings independent of the outside temperature. For public buildings this may be 68 to 72°F.

Apart from random irregularities, the outside temperature for a given locality follows diurnal and annual cycles. The most important climatic features which have a direct bearing on the design of space heating are:

1. The minimum outside temperature which determines the maximum energy required for heating; and

2. The number of degree-days over the year requiring heating, which governs the annual heating requirements. A "degree-day" is counted for each 1°F of ΔT from the desired indoor temperature on a 24-hour average.

The mean annual heating degree-days for Klamath Falls, averaged from 1966 to 1976, is 6976 DD/year. The extreme winter low temperature of record is -24°F. The mean temperature for a year is 45.6°F with the mean of July being 66.7°F and that of January 27.9°F. The average annual wind is 5.7 mph and the strongest average monthly wind is 7.3 mph in March. The climate in Klamath Falls is thus suitable for district heating because of the high load factor.

Figure 4 is a yearly temperature distribution curve for Klamath Falls. The curve shows the percent of time (i.e., number of days) over the year that has lower outside temperature than the given inside temperature of 70°F. The demand for heat is proportional to the difference between the inside design temperature and the outside temperature, and consequently the maximum demand for heat is proportional to the difference between the design room temperature and the minimum outside temperature. The shaded areas are proportional to the number of degree-days requiring heating and hence the energy requirements.

A heating system designed with sufficient power for handling the coldest day of the year by use of geothermal energy alone would obviously only run with partial load most of the year and would have a very low load factor. A system designed for handling only the maximum load represented by an outside design temperature of 25°F would handle all but 13 percent (47 days) of the heating requirements as shown on Figure 4. Thus, geothermal would supply the bulk of the energy required (90 percent - 13 percent = 77 percent or 281 days) over the year in a more economical way. The existing fossil fuel fired heating units can handle the heating requirements below the 25°F outside temperature when installed in parallel with the geothermal system.

Shown on Figure 7 are the estimates for monthly and yearly heating and geothermal fluid requirements for the ten building base plan. The 177,400 therms per year are based on the actual heating requirements, peak heat load and monthly degree days from Figure 6. The gallons per month of geothermal fluid required to heat the buildings were determined from the estimated heat load requirements and a 39°F temperature drop (184 to 145°F) between the producing and reinjection wells.

VI. DELIVERY SYSTEM

A. Introduction

The hot water utility must operate to deliver the water at specified minimums of temperature and pressure to each building throughout the range of demand flow. Demand is liable to vary widely due to it being a function of weather. One would expect flows on a cold winter day to exceed warm summertime flows by 20 to 1. Buildings with large demand fluctuations

FIGURE 4

YEARLY TEMPERATURE DISTRIBUTION IN KLAMATH FALLS

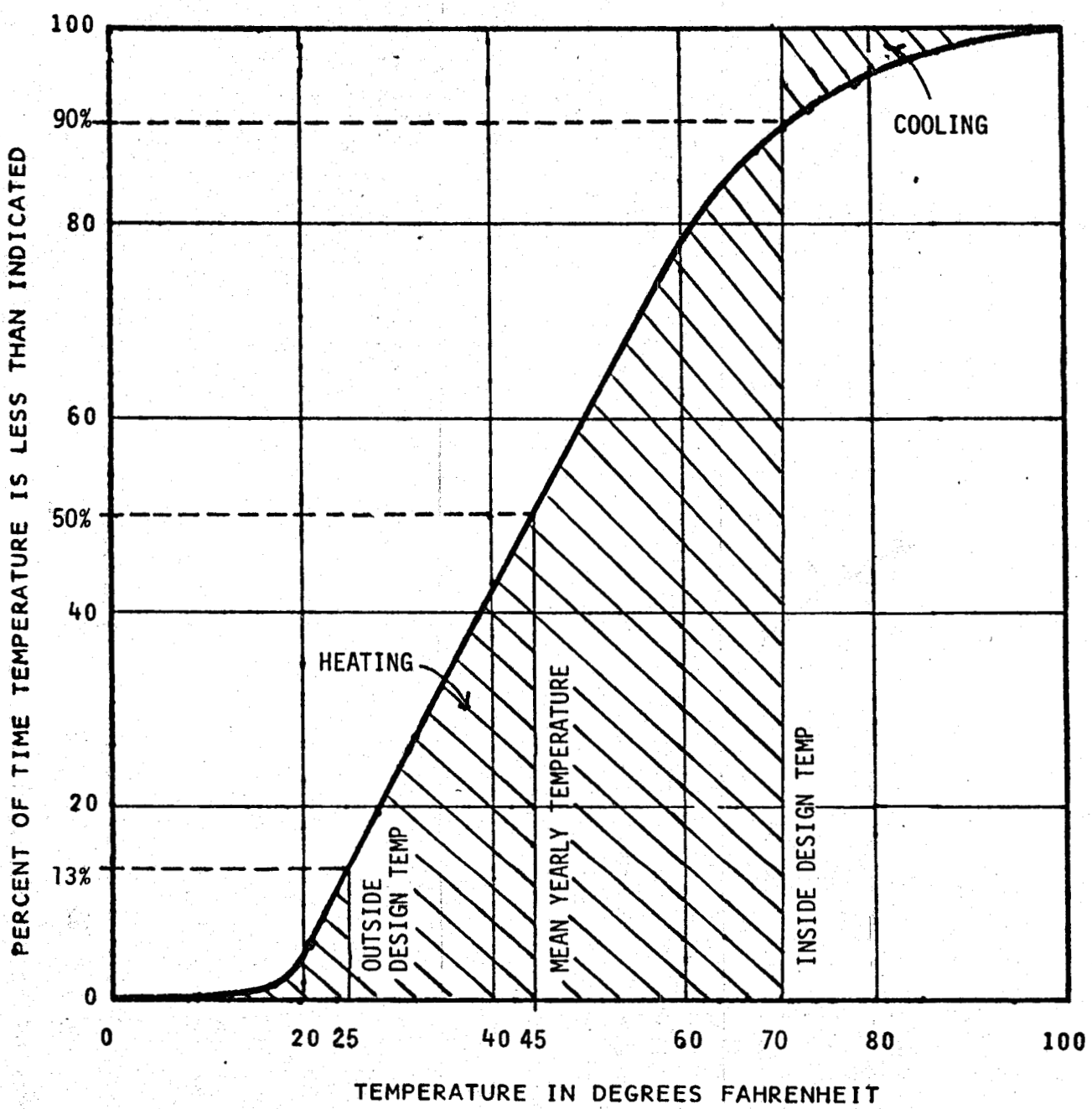


FIGURE 5

KLAMATH FALLS MONTHLY MEAN TEMPERATURE
1969 - 1976

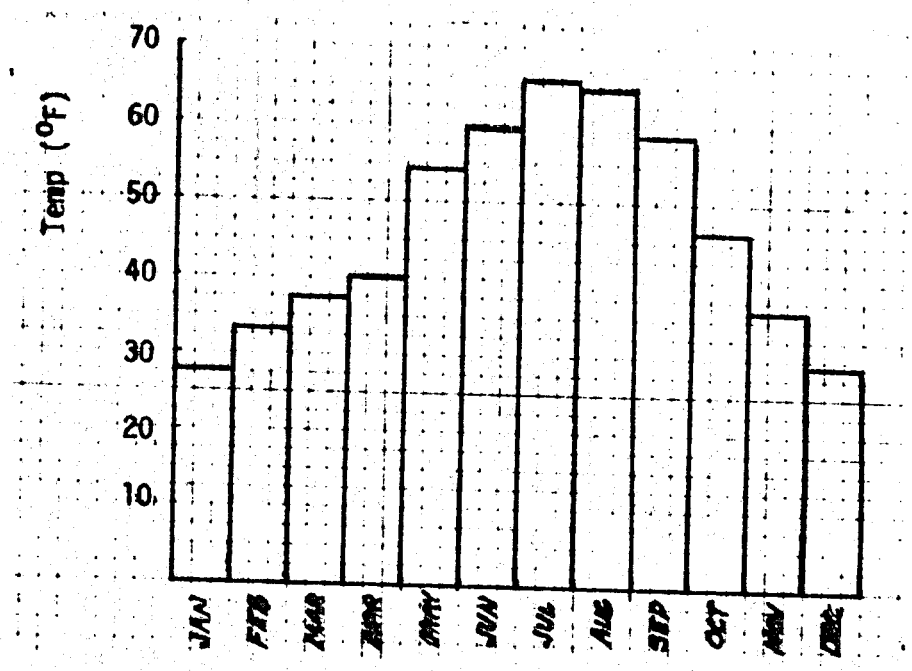


FIGURE 6

KLAMATH FALLS MONTHLY DEGREE HEATING DAYS
1966 - 1976

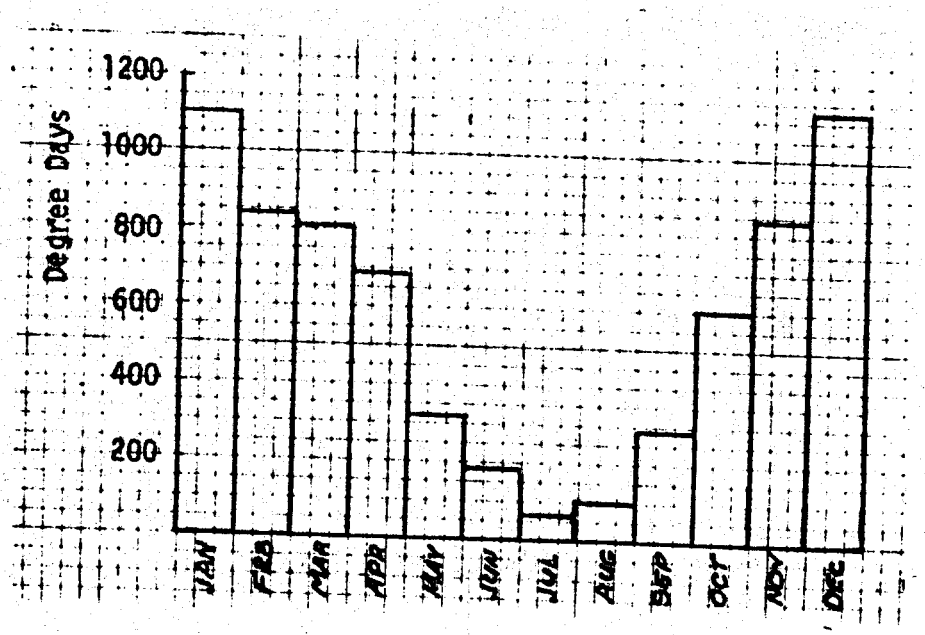
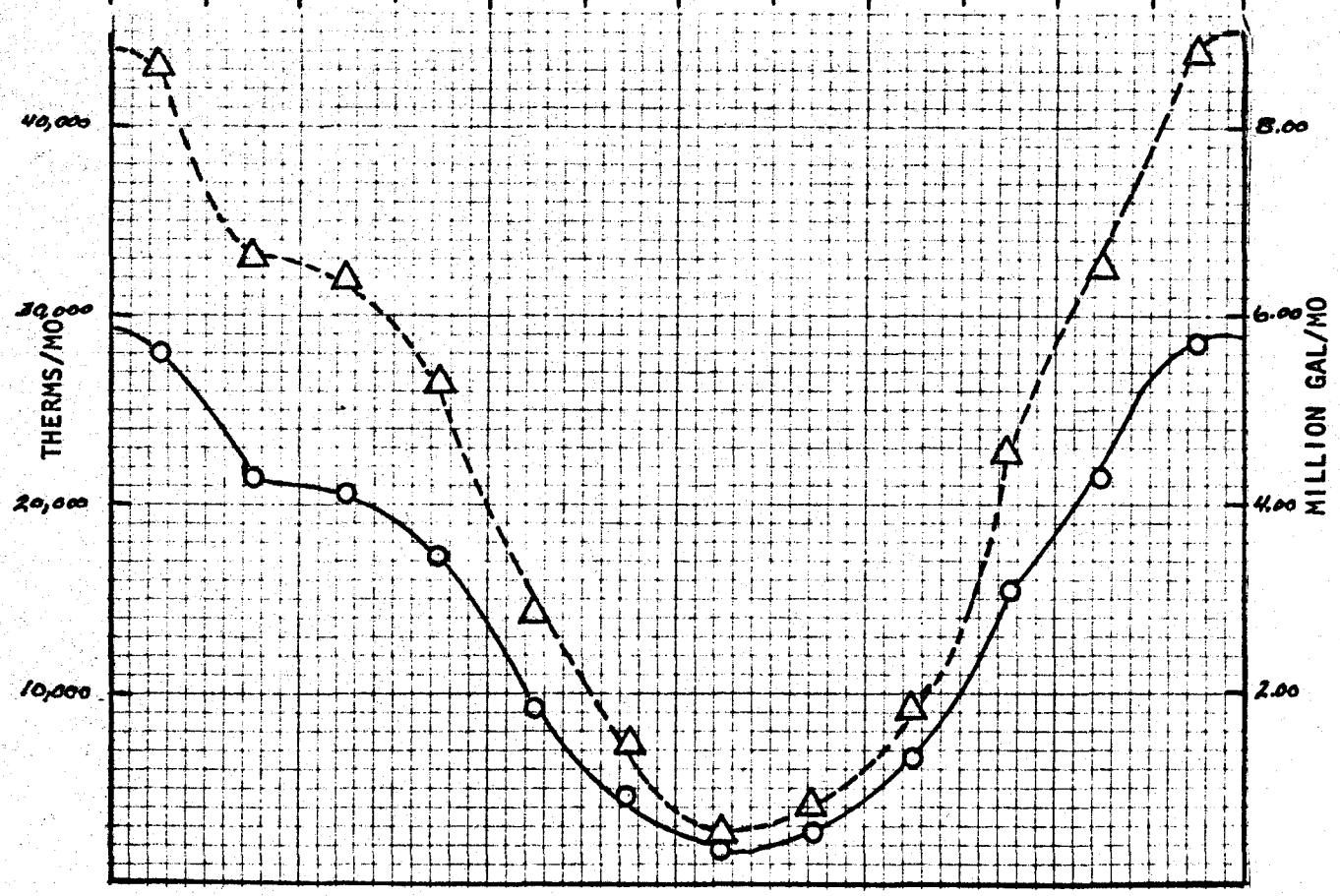


FIGURE 7

ESTIMATES ON MONTHLY THERM & GALLON REQUIREMENTS
BASED ON HEATING DEGREE DAYS FROM 1966 TO 1976

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Seven Co. Bldgs	23,300	17,900	17,300	14,400	7,700	3,900	1,400	2,100	5,400	12,800	17,700	23,800	147,700 THERMS/YR
Three City Bldgs.	4,700	3,600	3,500	2,900	1,500	800	300	400	1,100	2,600	3,600	4,800	29,700 THERMS/YR
TOTAL THERMS ○	28,000	21,500	20,800	17,300	9,200	4,700	1,700	2,500	6,500	15,400	21,300	28,600	177,400 THERMS/YR
MILLION GALLONS △	8.62	6.62	6.40	5.33	2.83	1.45	0.52	0.77	2.00	4.74	6.56	8.80	54.64×10^6 GAL/YR



and long supply lines will need to pump water beyond the required demand rates to maintain temperature for the buildings. Control of such a system is not complex. Operation of the major components, the pumps and valves, can be made automatic, requiring a minimum of operator monitoring by using conventional pneumatic and electronic controls.

In the studies of the distribution system two project sizes involving two different distribution schemes were investigated. The two different project sizes involve the base study (Line A - base plan) to convert ten public buildings with expansion to 12 to geo-heating and a larger one incorporating future expansion (Line B - expanded plan), as shown on Figure 8, with additional wells for geo-heating of the 12 public buildings plus downtown businesses (98 equivalent buildings) and a snow removal grid for Main Street.

B. Routes

The conceptual design of the project distribution system was based on the most economical and direct routes taking into consideration the abandoned Klamath Consumers Heating Company steam routes. A Consumer Heating line proceeds down the alley between Klamath Avenue and Walnut Avenue with a 24" x 24" tunnel from Fourth Street to an access (CH5) between Seventh and Eighth Streets. It appears that up to access point, CH5, no excavation will be required. The old Consumer Heating steam line can be removed from accesses CH1 through CH5 and the new line installed through the same accesses. Excavation will be required for supply and distribution lines, a distance of 4150 feet. The useable Consumer Heating tunnel from points CH1 to CH5, a distance of 1000 feet, will not require excavation. This line is designed to service the existing eight public buildings, post office, and allow for future expansion of one large public building in the vicinity of the courthouse.

The second alternative, shown on Figure 8, is to place a main service line under Main Street with service connections to businesses on Main Street between Eleventh and Fourth streets. The plan would initially connect the eight public buildings to the line. The line is sized to allow for future connections of the downtown businesses as more wells are drilled. Portions of the return would heat the Main Street pavement for snow removal.

C. Piping and Insulation

The selection of piping and insulation is dependent on corrosion, temperature and heat loss.

When pipes are located underground, external corrosion from ground water must be considered. In alkaline soils both asbestos cement and steel pipe are satisfactory but additional protection is normally provided for steel in the form of external coatings and in some soils cathodic protection is required.

FIGURE 4

GEOTHERMAL DISTRIBUTION SYSTEM

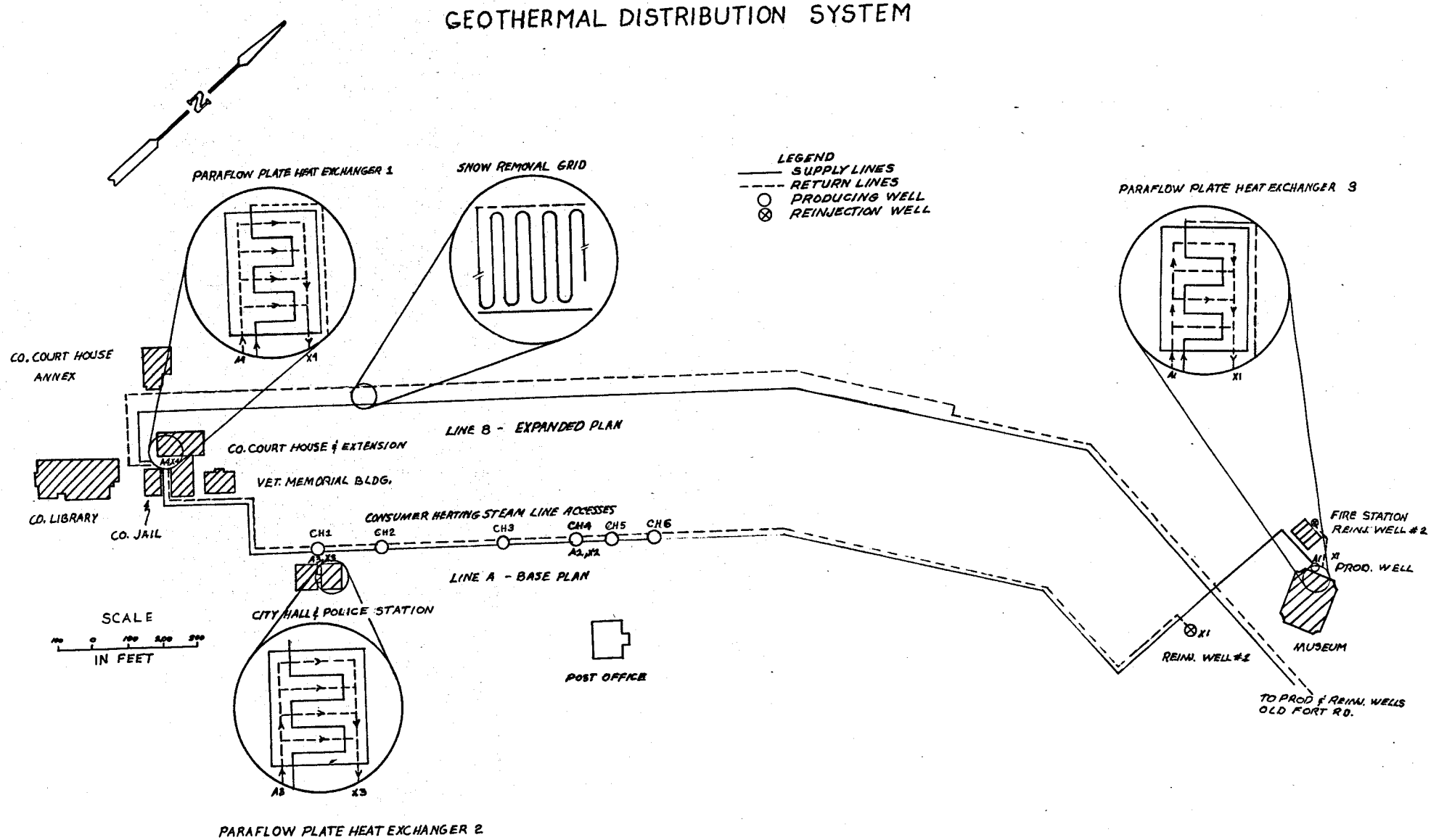


FIGURE 8a
DISTRIBUTION SYSTEM

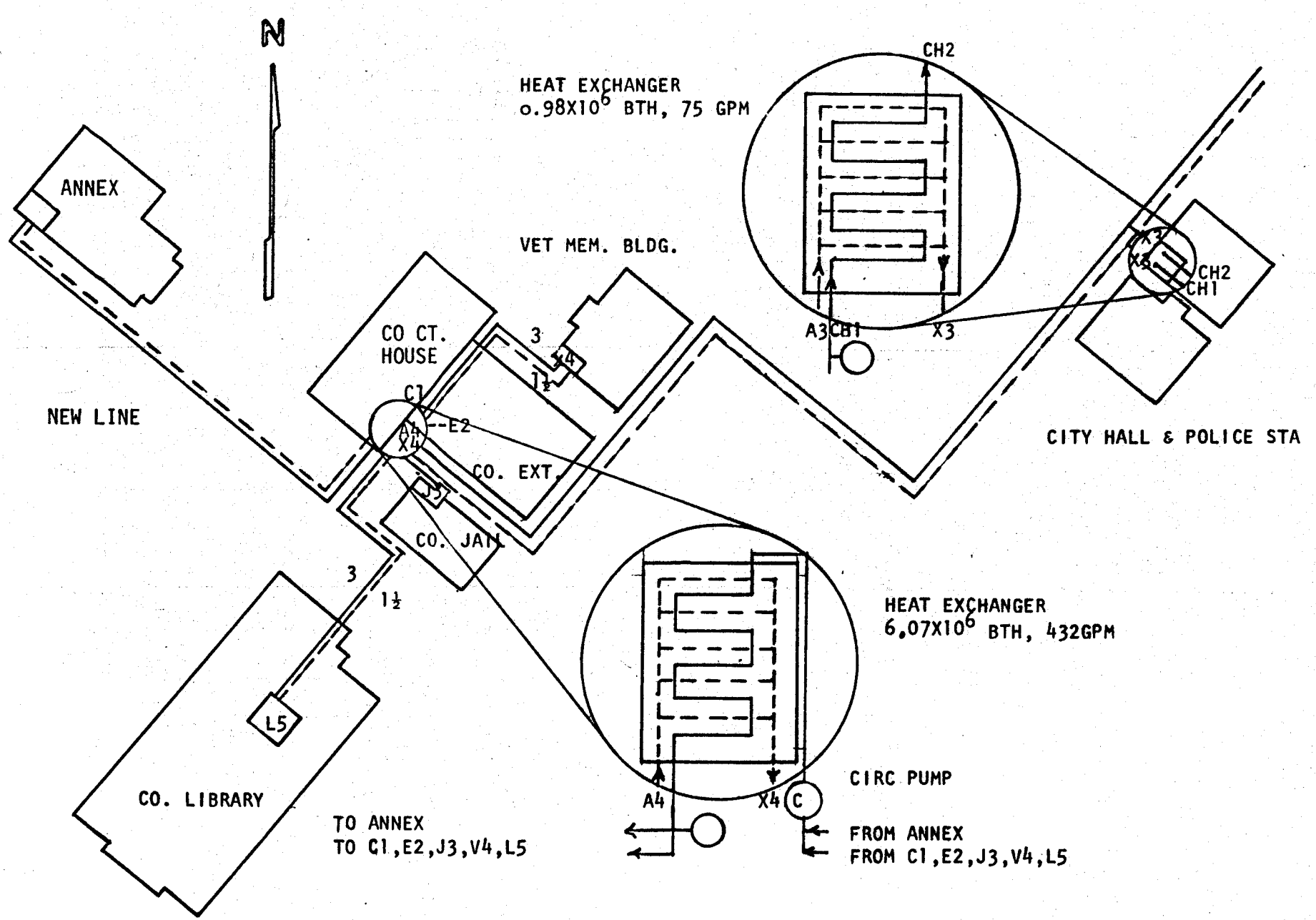
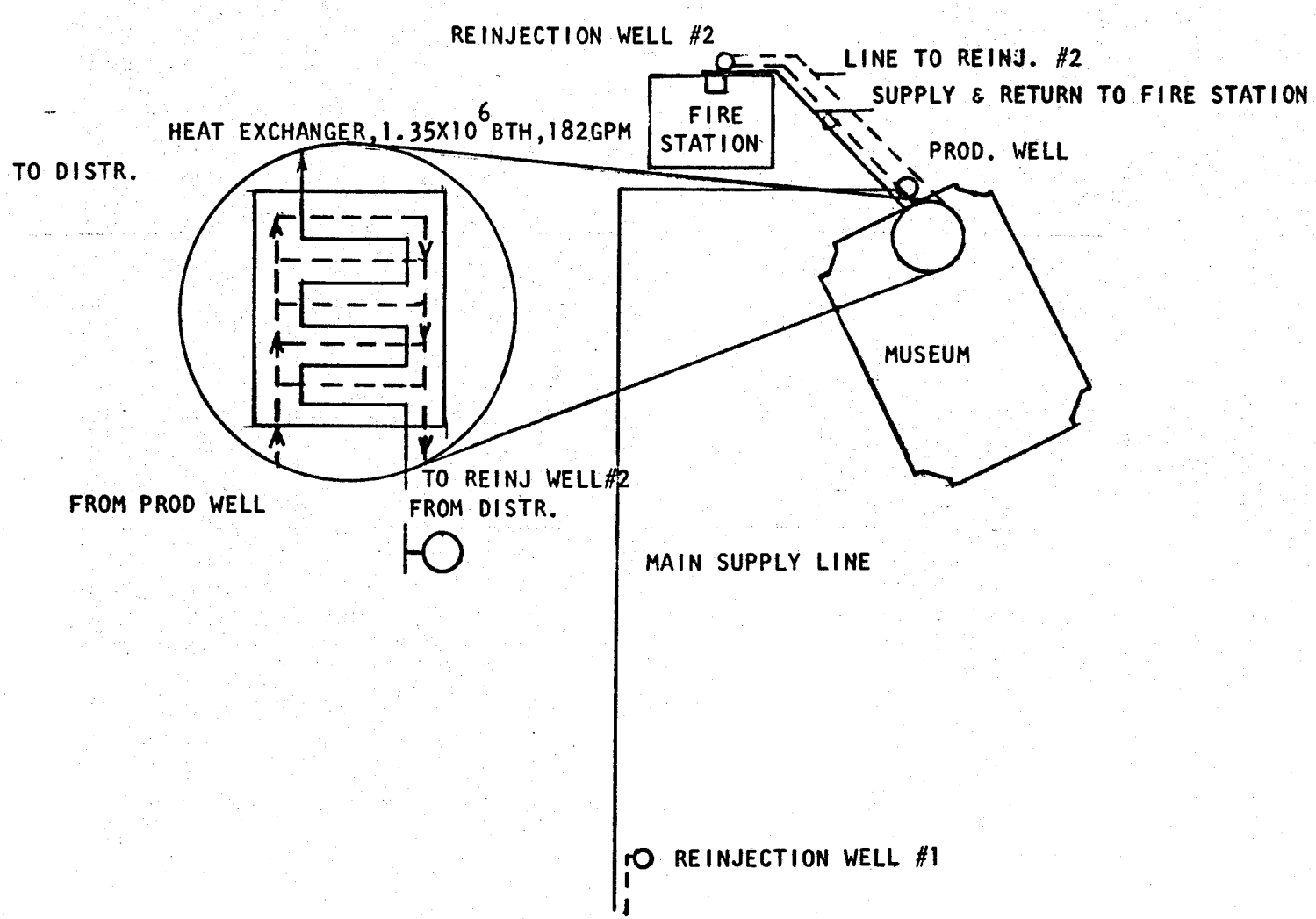


FIGURE 8b
DISTRIBUTION SYSTEM
FIRE STATION and MUSEUM



Asbestos cement pipe is suitable for temperatures less than 210°F. This is a limiting temperature for the elastomer seals used in the slip type expansion joints between pipe sections. Slip type joints are especially advantageous since they reduce installation costs. Above 210°F steel pipe or factory insulated asbestos cement pressure pipe is the recommended material with welded expansion loops placed at suitable intervals along the line for the steel pipe. Since the water temperature will probably be less than 190°F it is recommended that asbestos cement pipe with slip type expansion joints be used for the hot water transmission line.

Factory insulated or site insulated (field applied) piping is available for the supply lines. Another arrangement is to simply install asbestos cement pipes in a trench and to pour in granular insulation over the pipe. The manufacturer claims the insulation is water resistant, seals the pipe and protects it from corrosion in the case of steel piping.

Factory insulated asbestos cement underground pipe that is completely non-metallic could be used for the supply line. Polyurethane foam insulation is bonded between a transite casing and a transite core that provides maximum flow rates (C=150) and eliminates internal corrosion. Ring-tite couplings with rubber rings provide a water-tight seal that permits quick easy assembly and allows expansion and contraction in the joint. Pipe sizes are available from 3 to 30 inches. The recommended design temperatures for the 3- through 10-inch pipe sizes are 210°F and an operating pressure of 130 psi. For pipes sizes 12- through 30-inch the recommended maximum water temperature is 200°F and operating pressure 150 psi.

A bare asbestos-cement product pipe may be field insulated for the supply line and uninsulated for the return line. The pipe is available in sizes 4- through 16-inch and comes in 10- and 13-foot lengths. Expansion and contraction occur in the ring-tite joints similar to the factory insulated asbestos cement pipe. The field applied insulation may be foamglass with a mastic overlay that has proven successful in the OIT installation.

Comparisons of the non-insulated, factory insulated and field insulated piping are shown on Table 1.

TABLE 1

Comparison of Hot Water Pipelines

Type Pipe Systems		Description	Size (in)	Heat Loss BTUH/Lineal ft.
1. Non-insulated	a.	Class 150 Transite pipe is an asbestos-fiber reinforced product.	4 8 16 3 4	197 244 307 228 243
	b.	Schedule 40 Carbon Steel.	8 16	294 368
2. Factory Insulated	a.	Temp-Tite, Transite casing with polyurethane foam insulation and transite, lined core pipe.	3 4 8 16	26 23 40 82
	b.	Insul-8 (Rovanco Corp), Fiberglass reinforced (FRP) carrier pipe, urethane foam insulation in a PVC jacket.	3 4 6	22.3 31.4 46.3
3. Site Insulated	a.	Class 150 Transite pipe insulated with foamglass, black mastic and asphalt at site.	4 6	55 69
	b.	Gilso-Therm, insulation poured into open trench.	4 6	
	c.	Protexulate, insulation poured into open trench.	4 6	75 90

D. Size of Pipeline, Flow Characteristics and Insulation Requirements

The computations for the columns on the Pipeline Data Sheet (Table 2) were determined by the following:

1. Flow Rate

Flows are measured in GPM. Working back from each user the peak flows are determined for each line segment.

2. Pipe Diameter

Pipe sizes are based on peak flow velocities of 5 ft/sec, calculated where D is ID in inches and R is flow in lb/hr.

$$D = 0.01303(R)^{1/2}$$

$$D = 0.01303(807 \text{ GPM} \times 500 \frac{\text{lb/hr}}{\text{GPM}})^{1/2}$$

$$D = 8.28 \text{ in.}$$

3. The length, in feet, of each section of pipe is determined from the map scale.

4. Elevation change is the differences between the inlet and discharge of the line which are read directly from the contour lines on the city map.

5. Head Loss

Head loss is the difference between the elevation at inlet and discharge of the line and frictional losses; 10 percent is allowed for connections, fittings and valves, calculated from the William and Hazen formula (C=150).

6. Heat Loss

Heat loss per lineal foot for a single buried pipe was calculated from:

$$Q = \frac{KL\ (To - Ts)}{6 \ln 4\ (N/D)}$$

Where,

K = soil conductivity in BTU/ft^2 - HR - °F - in

L = length in feet

To = pipe outer surface temperature in °F

TS = ground surface average temperature in °F

N = depth of pipe centerline below the surface in feet

D = pipe diameter in feet

The lines are to be buried in a 4-foot deep trench with appropriate spacing of supports, thrust blocks, and access areas. Heat losses were determined assuming a soil conductivity of 12 BTU/ft^2 - H - °F with an average surface temperature of 35°F. A dual pipe system (supply/return) buried in the same trench has about a 15 percent less heat loss in the supply line than a single buried pipe.

7. Temperature Drop, ΔT

ΔT, °F is the temperature loss in degree farenheit for each segment of pipe during average winter flow. The average winter flow rate is estimated to be 47 percent of the peak based on the winter monthly degree days. The following formula was used to calculate temperature loss:

$$\Delta T = \frac{Q}{C\ R}$$

Where,

Q = heat loss in BTU/H

C = specific heat of water, 1.00 $\frac{BTU}{lb°F}$

R = average winter flow rate in lb/H

If the calculations indicate too great a temperature loss for uninsulated pipe, use insulated pipe.

8. Return Temperature Loss, Tout

Tout in °F is the temperature of the water leaving the segment and mixing with the water in the return line. It also takes into account temperature loss due to the building heating system.

E. Power Required by Pumps

1. Well Pump

The power required by the well pump in KW is calculated from the formula:

$$P = 6.817 \times 10^{-7}\ R \times h$$

Where,

R = water flow in lb/H

h = head of water in feet

$$P = (6.817 \times 10^{-7})\ (989\ GPM \times 500\ \frac{lb/H}{GPM})\ (100\ ft)$$

$$P = 3.4\ KW$$

To convert to brake horsepower, multiply KW by 1.341

$$P = 45\ hp$$

Efficiencies for the motor and pump incorporated into the formula are 80 and 65 percent respectively.

TABLE 2

PIPELINE DATA SHEET

	1.		2.	3.	4.			5.	6.		7.		8.	
	Flow Rate				Elevation (ft)				Heat Loss BTU/Hr x 10^4		ΔT, °F pk/avg. flow	ΔT, °F pk/avg. flow	Tout, °F avg. flow	Tout, °F avg. flow
Line No.	Peak GPM	Velocity ft/s	I. D. in.	Length ft.	in	out	Δ	Head Loss psi	Insul	Noninsul	Insul	Noninsul	Insul	Noninsul
MAIN SUPPLY LINE, LINE A - BASE PLAN, Tout = 184°F (Museum Production Well)														
A1 to A2	807	5.3	8	2480	4111	4102	-9	9.3	9.92	60.5	.4/.8	2.4/5.0	183.2	179.0
A2 to A3	807	5.3	8	720	4102	4097	-5	1.7	2.88	17.6	.1/.2	.7/1.5	183.0	177.5
A3 to A4	732	4.7	8	900	4097	4098	+1	4.3	3.60	22.0	.2/.3	1.0/2.2	182.7	175.3
MAIN RETURN LINE, LINE X - BASE PLAN (Broad Street Reinjection Well)														
X4 to X3	732	4.7	8	900	4098	4097	-1	3.4	--	22.0	--	2.2	--	153.5
X3 to X2	807	5.3	8	720	4097	4102	+5	6.0	--	17.6	--	1.5	--	148.9
X2 to X1	807	5.3	8	1930	4102	4108	+6	12.8	--	47.1	--	4.0	--	144.9
DISTRIBUTION SYSTEM (SUPPLY/RETURN) FOR LIBRARY, VET. MEM., CO. JAIL & ANNEX, Tout = 165, Tin = 138														
Lib - S	90	4.3	3	250	4098	4095	-3	1.4	0.65	4.48	.15/.3	2.1	165.0	
Lib - R	90	4.3	3	250	4095	4098	+3	4.0	--	4.48	--	2.1	122.6	
Vet - S	34	1.6	3	170	4098	4098	0	0.1	0.44	3.04	.3/.6	3.8	165.0	
Vet - R	34	1.6	3	170	4098	4098	0	0.1	--	3.04	--	3.8	140.6	
Jail - S	59	2.7	3	50	4098	4096	-2	-0.6	0.13	0.90	.04/.09	0.7	165.0	
Jail - R	59	2.7	3	50	4096	4098	+2	1.1	--	0.90	--	0.7	144.2	
Annex - S	21	1.0	3	380	4098	4108	+10	5.0	0.99	6.80	.9/.2	13.8	165.0	
Annex - R	21	1.0	3	380	4108	4098	-10	-3.7	--	6.80	--	13.8	109.2	
Fire Sta - S	39	1.8	3	150	4111	4111	0	.7	0.39	2.96	.2/.09	1.52	165.0	
Fire Sta - R	39	1.8	3	150	4111	4111	0	.7	--	2.96	--	1.52	136.3	

2. Booster Pump for Distribution

The power required to circulate the water in the distribution lines and heat exchangers is calculated from the formula in part (1).

$$P = (6.817 \times 10^{-7})\ (989\ GPM \times 500\ \frac{lb/H}{GPM})\ (225\ ft)$$

$$P = 76\ KW$$

$$P = 100\ hp$$

F. Controls for Heat Supply System

Heat load demand will vary widely, being a function of weather and differences between day and night temperatures. The flow from the well should match the variations in heat load to meet the demand. Pumping at varying rates minimizes the effect of drawdown on neighboring wells and conserves the resource.

The pumping system consists of a 100 horsepower electric motor connected to a torque converter unit, which in turn drives a 10' x 8" diameter bowl assembly at the end of a 100-foot shaft. As shown in Figure 11, the well and booster pump operate on demand, controlled by pressure in the supply line. The pressure in the supply line is controlled by a proportional temperature control, valves and modulated motor actuator located at each heat exchanger. When the temperature in the primary discharge side of the heat exchanger reaches a preset high value, the valve automatically closes, increasing the pressure in the line and thus slowing down the pump by means of the torque converter.

On the secondary sides of the heat exchangers parallel insulated and non-insulated 3-inch lines distribute heated water to the buildings. A circulation pump and expansion tank are required for these three closed loop systems. Building heating controls are presented in section VII of this report.

G. Materials of Construction

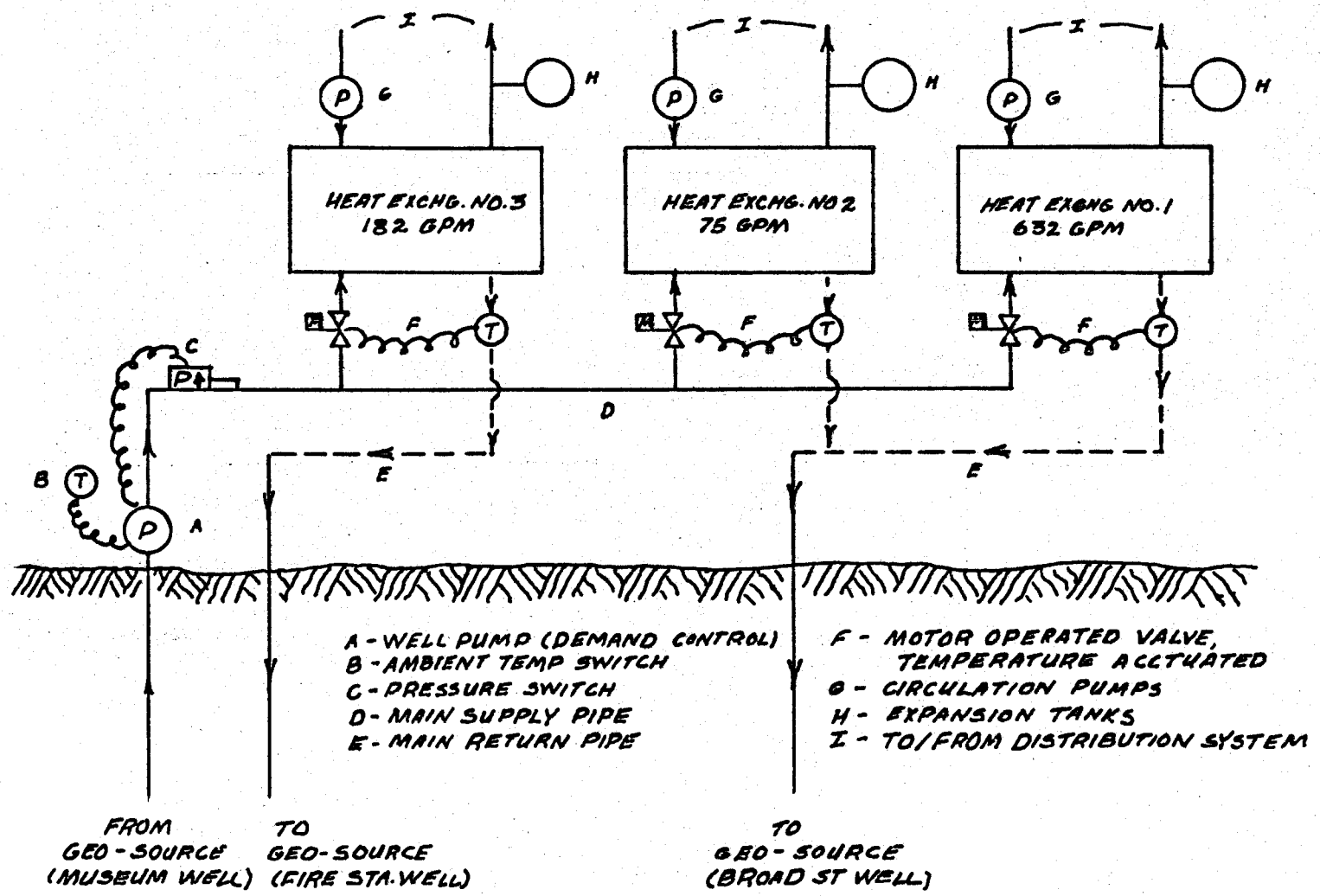
Materials must be selected to provide adequate strength and to resist chemical attack. The design of components for the hot water system should have lives of 30 years or more.

The primary process variables which affect material selection are:

Temperature of the hot water
Pressure
Chemistry of the geothermal waters and of the ground
Heat losses

FIGURE 9

CONTROLS FOR HEAT SUPPLY SYSTEM



The temperature of the museum well water, based on the pump test, July, 1976, was held at 184°F with a flow rate of 670 gpm. Insulated or non-insulated asbestos cement pipe would be satisfactory since the water temperature is less than 210°F.

Chemical analysis of Klamath Falls geothermal waters was performed by OIT for Lawrence Livermore Laboratories. Fifty water samples from 46 wells were analyzed for chemical concentrations, alkalinity and water hardness (see Figure 10). Figure 10a is the chemical analysis results for a sample taken from the museum well water during the pump test.

The alkalinity values ($\sim$ pH = 8.3) indicate the major contributor to pH is the bicarbonate ion and these waters are highly susceptible to downward pH shifts.

Scaling is primarily due to silica (70-90 mg/l) and calcium carbonate ($\sim$ 40 mg/l) concentrations. Studies of the Langelier Saturation Index (deposition vs. dissolving) indicate that waters in these wells tend to deposit calcium carbonate rather than dissolve it. This problem appears to be minimal in Klamath Falls geothermal water. Artesian wells have a high saturation index, resulting in a downhole heat exchanger repair frequency of between 29 and 34 years, whereas non-artesian wells with low index have a 14-year average repair frequency. The latter reduction in service life is due to an air-water interface .

The following basic materials recommended for this preliminary design are (Appendix B presents material technical data and estimating prices):

1. Pipe - factory insulated and bare asbestos cement pipe. Insulated asbestos cement pipe is recommended for the supply line due to the temperature drop when small flow rates occur in the line. Non-insulated asbestos cement is recommended for the return lines. A decision for non-insulated supply and return lines (approximately 50 percent of the cost of insulated supply lines) should be made by the developer if he wishes to sacrifice increased use of fossil fuels for peaking. Insulated and bare carbon steel piping would also provide satisfactory service; however, it is about 25 percent more expensive than transite.

2. Pumps are fabricated from carbon steel.

3. Heat exchangers are paraflow plate type. The plates are fabricated from 316 stainless steel which has been found to be the most resistant to scaling and corrosion.

4. Snow removal grid - 1-inch PVC on 18-inch centers.

FIGURE 10

WELL WATER CHEMISTRY

KEY

WH - Water Hardness
Ca - Calcium
Na - Sodium
K - Potassium
TA - Total Alkalinity
Cl - Chloride
SO_4 - Sulfate (divided by 2)
SiO_2 - Silica

HOT WATER WELL
HOT WATER WELL (ARTESIAN)
COLD WATER WELL

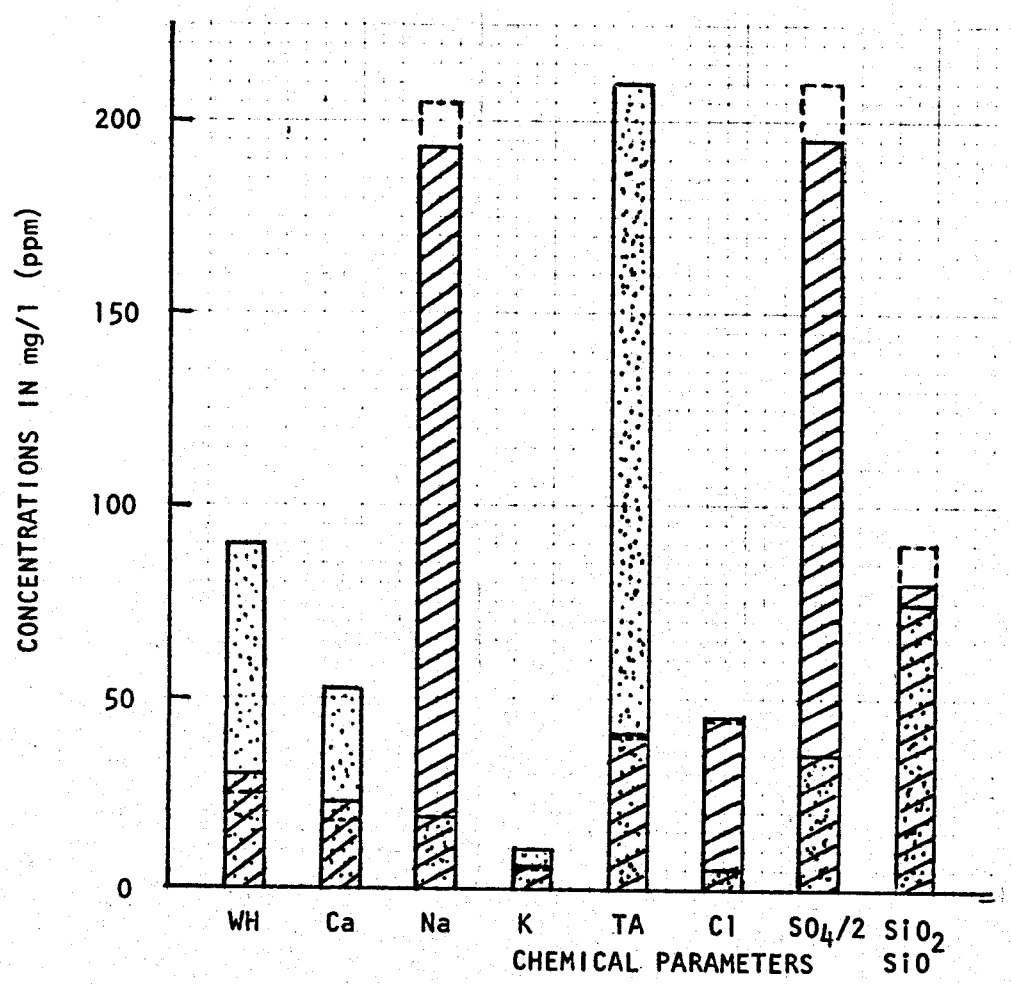


FIGURE 10a
MUSEUM WELL
GEOCHEMISTRY OF WELL WATER

Date Sample Taken:		8/27/76
1.	Temperature of Sample:	69°C
2.	Sodium (mg Na/l):	200.
3.	Potassium (mg K/l)	3.8
4.	Total Water Hardness (mg $CaCO_3$/l):	59.6
5.	Calcium (mg Ca/l):	23.5
6.	Alkalinity to pH 8.3 (mg $CaCO_3$/l):	0
7.	Alkalinity to pH 4.5 (mg $CaCO_3$/l):	44.0
8.	Chloride (mg Cl/l):	51.0
9.	Sulfate (mg SO_4/l):	377.
10.	Silica (mg SiO_2/l):	95.9
11.	Total Dissolved Solids (mg/l):	924.
12.	Iron (mg Fe/l):	0.52
13.	pH:	8.30
14.	Conductivity, μv/cm:	1070

VII. BUILDING CONVERSION TO GEOTHERMAL (RETROFIT)

A. General Design Considerations for Establishing the Building Peak Heating Load

An outdoor design temperature of -10°F, wind velocity less than 15 mph, and an indoor temperature of 75°F were used in making heat load calculations for this study. ASHRAE Handbook of Fundamentals (1972), Chapter 20 tables were used as reference for design heat transmission coefficients and infiltration losses. The calculated heating load (based on building plans and field observations), rated heating system capacity, fuel consumption data and building users' comments were considered in establishing a value for the heating requirements (see Table 3) of each building.

B. General Retrofit Considerations

Three types of heating systems are presently being used in the buildings: 1) forced air systems; 2) steam boiler systems which circulate steam through the building radiators or use steam to heat water which is in turn circulated through the building radiators; and 3) hot water systems that circulate hot water through the building radiators.

The following considerations were taken into account in the retrofit design of the heating systems: 1) placement of three heat exchange devices; 2) system configuration and heat exchanger design to obtain optimum use of the geothermal fluid; 3) minimal disturbance of existing air or water flow by new devices; 4) provision of control systems with a minimal number of expensive control devices; 5) selection of materials for compatibility with the geothermal fluid; and 6) minimization of cost of new components.

All of the existing heating systems will remain as backup or peaking systems to the geothermal systems that will be installed. The existing steam and hot water systems will be connected in series-parallel with the geothermal supply.

We have evidence that direct use of hot water from the wells in the Klamath Falls area causes accelerated corrosion to occur in heating units. If direct use of geothermal well water were implemented, heating units may be expected to remain in service for only five to 12 years before replacement becomes necessary. We have had little experience with direct use of geothermal fluid in boilers or convectors. Thus we are hesitant to condone direct use of geothermal fluid in any type of heating system. All heating systems in this project are designed to be isolated from contact with geothermal well water by interfacing system heating water with geothermal well water through a water-water heat exchanger. Since 100 percent heat transfer from geothermal water to system water is not possible, the building heating systems will not receive hot water at the temperature of the well water but at some lower temperature.

TABLE 3

BUILDING DATA SHEET

Building	Building Size (ft^2)	Heating Systems	Heat Load BTU/Hr x 10^6 Peak	% PK with existing convectors	Temp (°F) In	Temp (°F) Out	Water Flow GPM Peak
Museum	21,700 (1 floor)	Hot Water	1.430	57	165	145	143
Fire Station	9,280 (2 floors)	Hot Water	0.529	100	165	138	39
City Hall	11,607 (2 floors & basement)	Hot Water	0.696	63	165	145	52
City Police Station	3,900 (1st floor 2,400 (2nd floor)	Hot Water - Forced Air	0.282	55	165	130	16
Courthouse	24,960 (3 floors)	Hot Water - Forced Air	1.280	100	165	133	80
Courthouse Ext.	24,960 (4 floors)	Hot Water - Forced Air	1.474	100	165	145	148
Veterans Memorial	13,920 (2 floors & basement)	Steam	0.527	53	165	134	34
County Jail	8,900 (2 floors)	Steam	0.590	53	165	145	59
Library	23,276 (1st floor) 4,524 (2nd floor)	Hot Water - Forced Air	1.783	65	165	125	90
Courthouse Annex	16,500 (3 floors & basement)	Hot Water - Heat Pump	0.418	100	165	125	21
Total for existing buildings			9.009				682
FUTURE EXPANSION							
Future Public Building	31,000 (est.)		2.00 (est.)	100	165	125 (est.)	100
Post Office	54,100 (3 floors & basement)		3.00 (est.)	100	165	135 (est.)	200
TOTAL	251,000		14.009	79			982

In many cases the forced air coils, unit heaters, etc., were originally designed to operate at up to 200°F. The geothermal heat exchangers will supply water at 165°F, resulting in the geothermal system being able to supply from 53 to 100 percent (see Table 3) of peak heating load requirements, depending on the building system. If the existing boilers were used to supply the heat not supplied by the geothermal system, they would furnish 11 percent of the 177,400 therms or 19,500 therms per year. This would cost $4,900 per year for natural gas based on the 1976 rate. Pay-off of the additional convectors would be in 7.1 years at this rate.

C. Controls

The control system for geothermal conversion will be compatible with controls already installed in the building. Switchover from straight geothermal heating to geothermal with furnace peaking will be facilitated automatically in the furnace room.

The control scheme for the five buildings in the courthouse area utilizing heat exchanger No. 1 is described in the following section.

1. Control sequence for heat exchanger No. 1

The method for controlling flows to the five buildings from heat exchanger No. 1 is as follows.

BOILER VALVE	NORMALLY CLOSED	
3-WAY MIXING VALVE .	NORMALLY ON BOILER BYPASS	see Figures 11 & 12
GEO RETURN VALVE . .	NORMALLY CLOSED	
CIRCULATION PUMP . .	NORMALLY OFF	

a. Outside thermostat turns circulation pumps on when outside temperature is less than 70°F.

b. GEOTHERMAL MODE

Geothermal return valve modulates flow of geothermally heated water proportionally to room demand.

c. PEAKING MODE (combination geothermal and boiler)

If the rooms call for more heat when the geothermal return valve has reached full open position the geothermal return valve is locked into the full open position by the limit switch acting through the relay and the room thermostats then control the temperature of heating water by modulating the three-way valve. The limit switch on the geothermal return valve also renders the supply line thermostat active when the geothermal return valve reaches the full open position.

d. BOILER MODE

If the water in the return line reaches a predetermined high temperature (near the incoming geothermal water temperature), the high limit control acting through the relay closes the geothermal return valve (but keeps the supply line thermostat active), opens the boiler return valve, and leaves the three-way mixing valve under control of the room thermostats.

e. When the water temperature in the system return line drops to the low temperature set point of the high limit control, the system returns from boiler mode to the peaking mode of operation.

f. When the supply line temperature drops to the set point of the supply line thermostat, the system returns from peaking mode to geothermal mode.

This control system is fully automatic and will control the heating system in all modes of operation but it does not incorporate any control of the cooling system. It is recommended that the valves all be pneumatically actuated. The rest of the system can be electronic, pneumatic, or hybrid. Some of the buildings may operate better with a different control system or with modifications of the described system.

FIGURE 11

CONTROL DIAGRAM

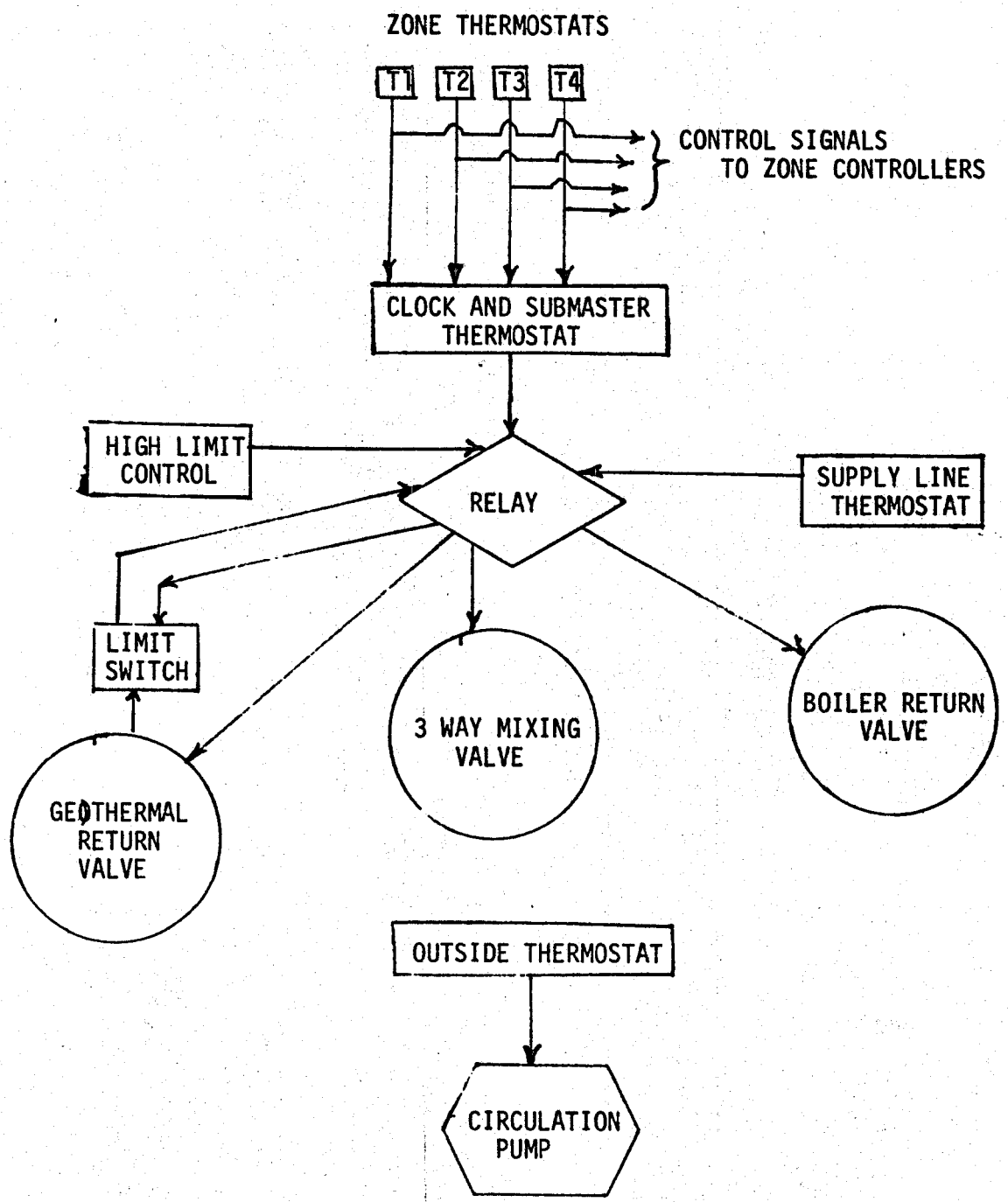


FIGURE 12

CONTROL COMPONENT KEY

A. CIRCULATION PUMP

B. SUPPLY LINE THERMOSTAT

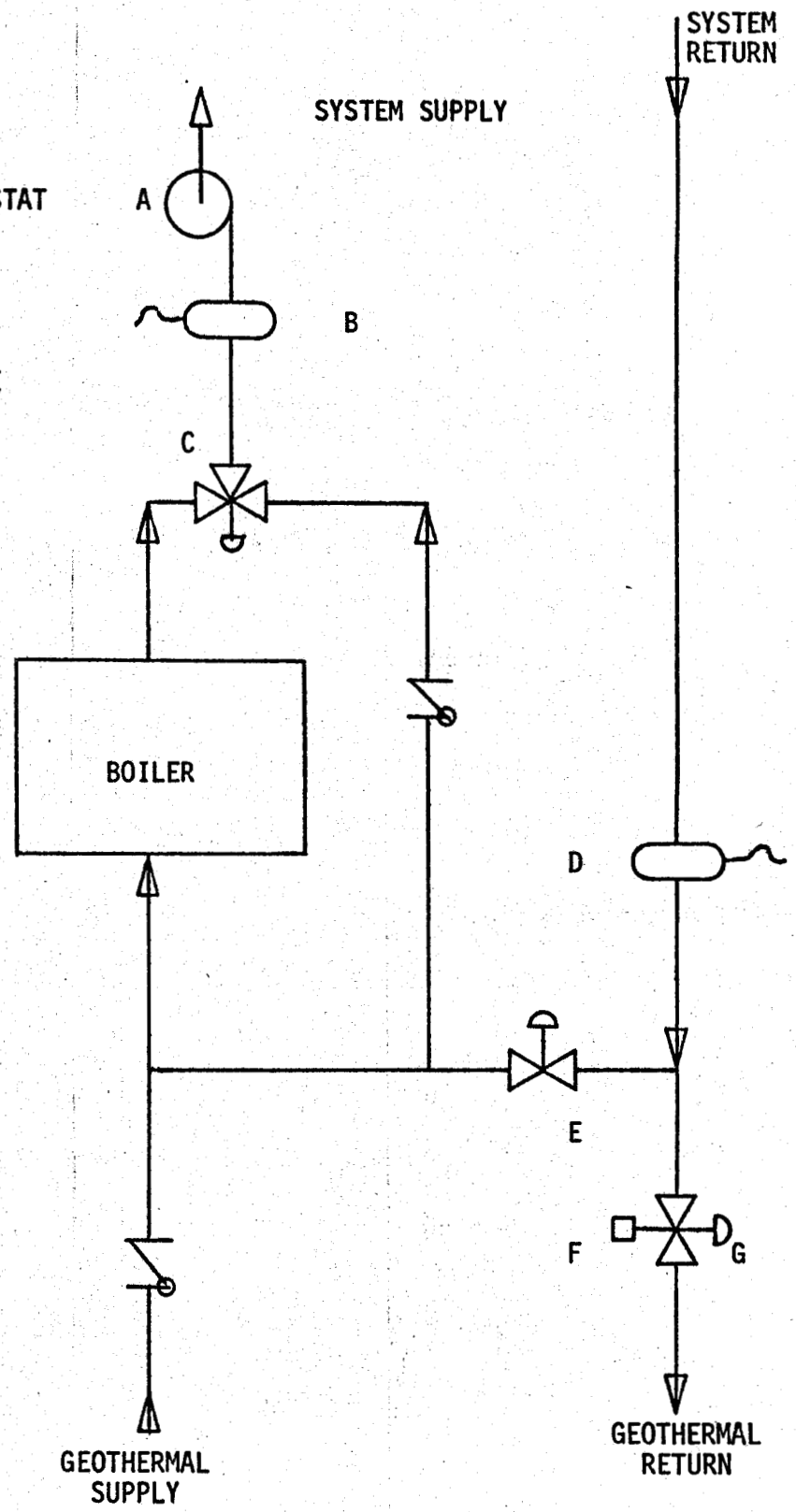
C. 3-WAY MIXING VALVE

D. HIGH LIMIT CONTROL

E. BOILER RETURN VALVE

F. LIMIT SWITCH

G. GEOTHERMAL RETURN VALVE



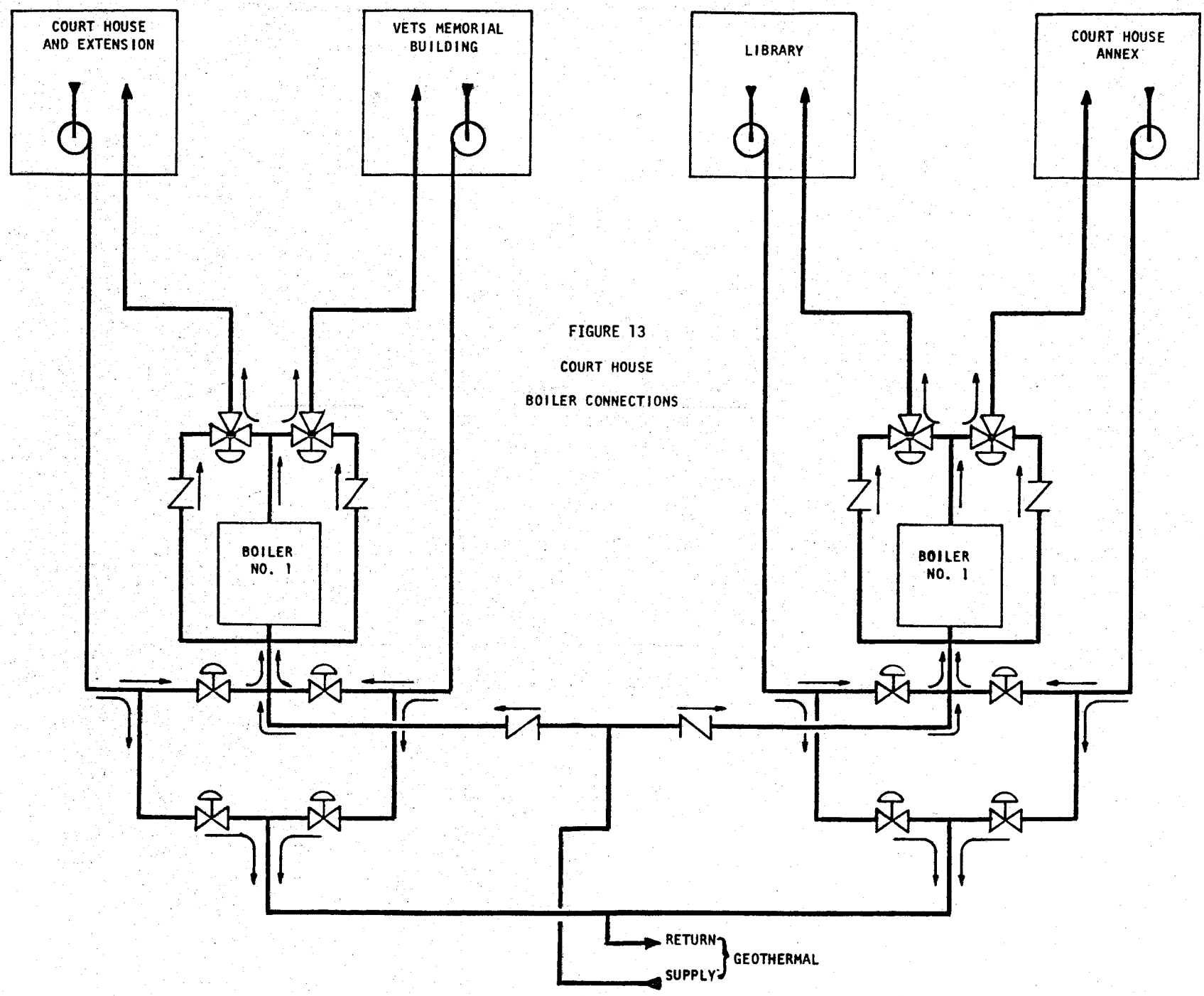


FIGURE 13

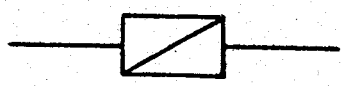
COURT HOUSE

BOILER CONNECTIONS

FIGURE 14

SYMBOLS

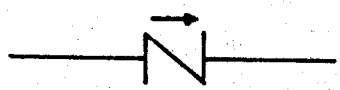
STRAINER



WATER METER

MANNUALLY OPERATED GLOBE VALVE

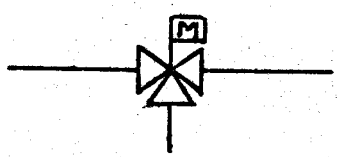
MANNUALLY OPERATED GATE VALVE



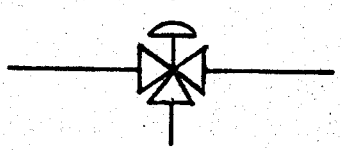
CHECK VALVE

MOTOR OPERATED GLOBE VALVE

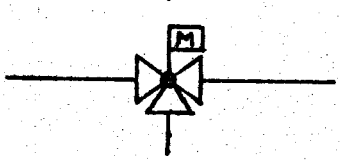
AIR OPERATED GLOBE VALVE



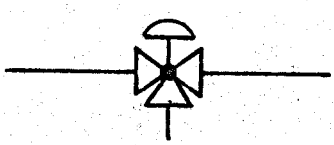
MOTOR OPERATED 3-WAY VALVE



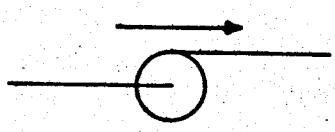
AIR OPERATED 3-WAY VALVE



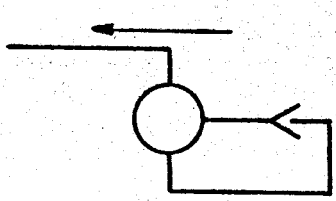
MOTOR OPERATED 3-WAY MIXING VALVE



AIR OPERATE 3-WAY MIXING VALVE

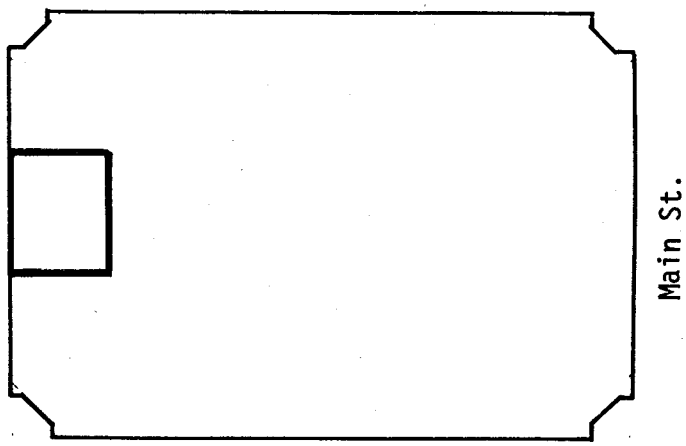


CENTRIFUGAL PUMP



IN WELL JET PUMP

D. Klamath County Museum Conversion



COUNTY MUSEUM
(Armory)

Est heat load 1,430,000
Est gpm 143 @ 165°F ΔT 20°

A brick structure with a high arched roof, constructed in 1934 and 1935, 21,700 square feet excluding the bleachers which are not used. The roof has recently been insulated and heat loss estimates include the insulation.

The building is presently heated by 37 cast iron radiators around the perimeter and five forced air fan coil units in the main exhibition hall. All units are essentially as originally installed although several radiators have been relocated. The heating system was originally on steam supplied by Consumers Heating. A hot water well now supplies heated city water at approximately 180°F. Although the system has operated satisfactorily since the hot well has been used, heat loss estimates vs. heat input estimates indicate that the building temperature would remain about 60-65°F during extended periods of outside temperatures just below 0°F.

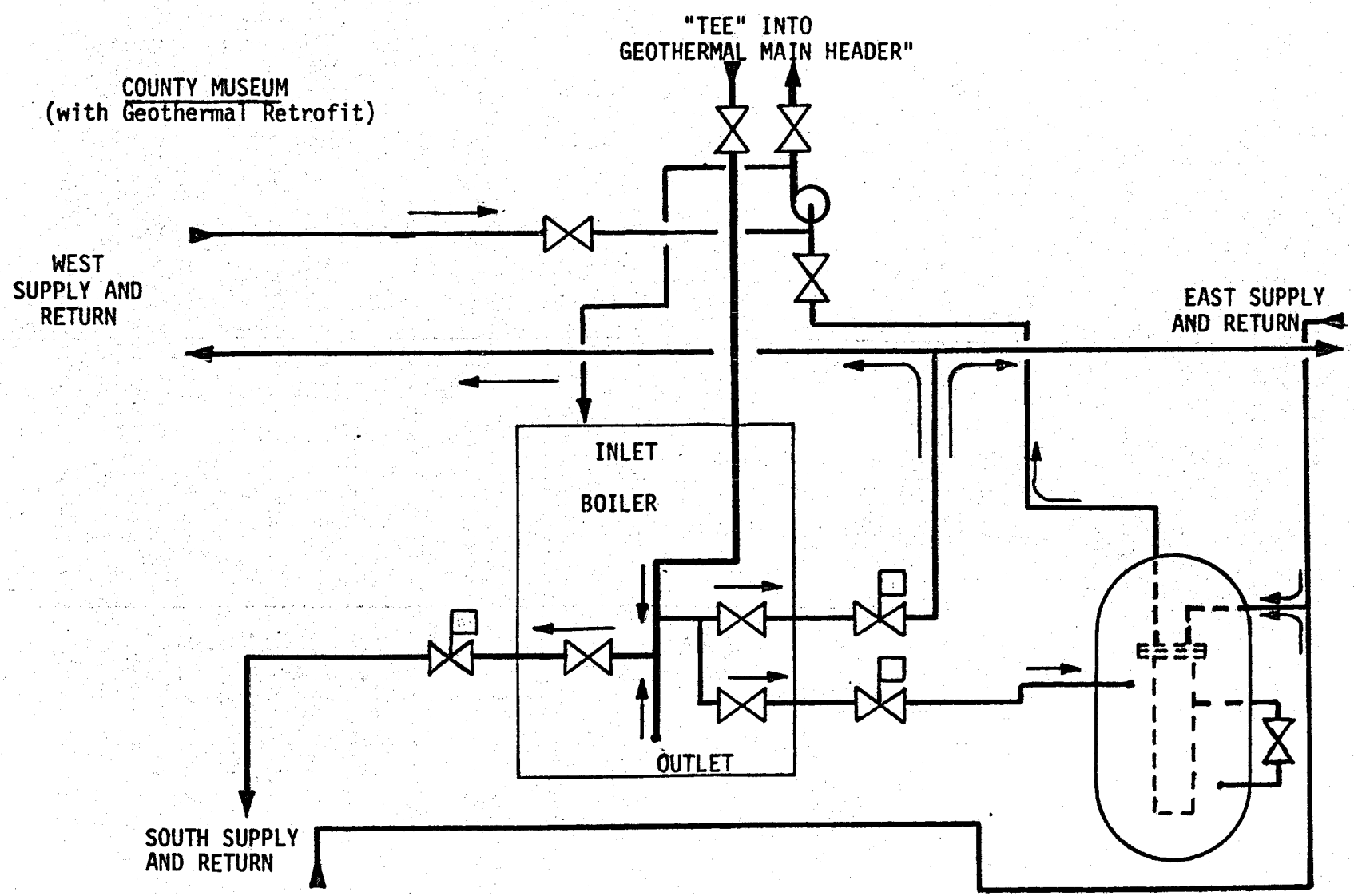
A geothermal system with plate heat exchanger supplying 165°F water would supply about 57 percent of the required heat using the present radiators and fan coils.

In order to supply the total required heat load with 165°F entering water, the radiators and fan coils would need to be replaced--the radiators by finned tube convectors and the coils by three-row finned tube units.

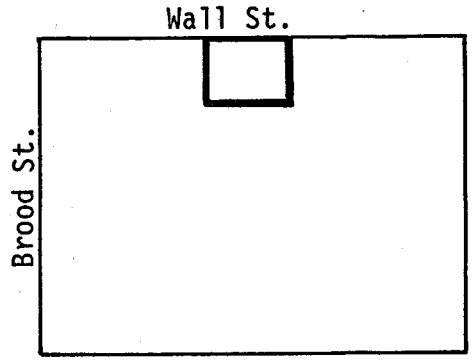
Estimated costs of retrofit*

convectors	$ 5,000
fan coils	1,500
labor and miscellaneous parts	5,600
control modifications	1,900
mechanical room including labor	3,000
TOTAL	$17,000

*Not including engineering (detailed room by room heat requirements and convector specification.


"TEE" INTO
GEOTHERMAL MAIN HEADER"
COUNTY MUSEUM
(with Geothermal Retrofit)
WEST
SUPPLY AND
RETURN
EAST SUPPLY
AND RETURN
INLET
BOILER
OUTLET
SOUTH SUPPLY
AND RETURN

E. Central Fire Station Conversion



CENTRAL FIRE STATION #1

Est heat loss 529,000 BTH
Est requirements 39 gpm 27 ΔT

The building is brick, two floors, with built-up roof reportedly with six inches of insulation in the roof. No building plans are available. The lower floor houses equipment with the upper floor being living quarters for the on-duty firemen. Heat losses are large for a building of this size because of the large equipment doors on the lower floor and excessive infiltration losses around windows on the upper floor.

The building is presently heated by a 148°F hot water well being pumped directly through cast iron radiator and fin tube convectors. An auxiliary fan coil unit is used on colder days. The present heating system is reported to be inadequate on cold days with drafts being objectionable.

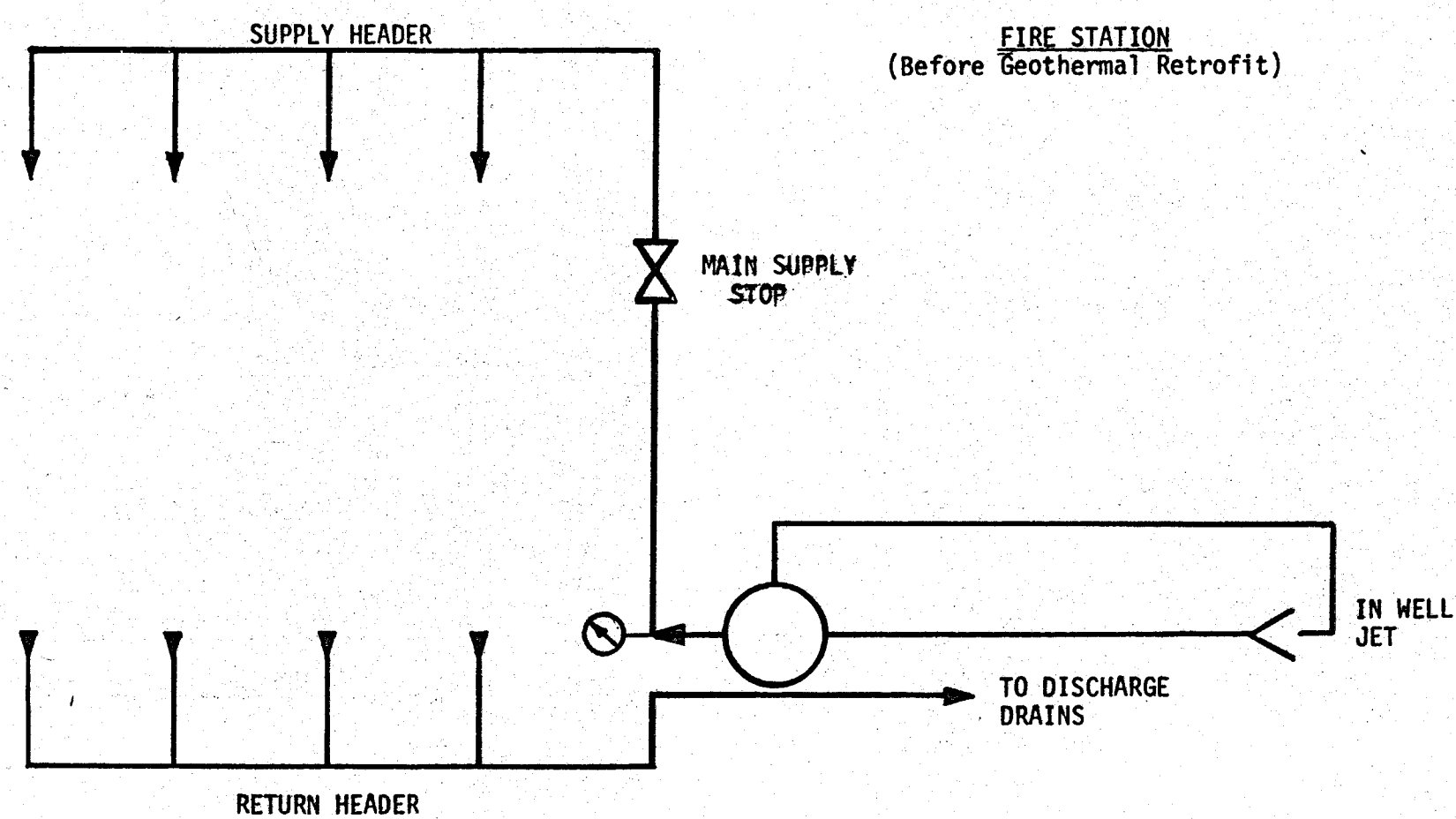
If a geothermal system supplies water to the building at 165°F, the heat output of the building radiators and fin tube units will be increased approximately 40 percent and will provide adequate heat. A new circulating pump will be required.

Although the system will provide sufficient heat, the elimination of drafts around doors and windows would make the building much more comfortable. New windows should be installed and equipment doors properly weatherstripped.

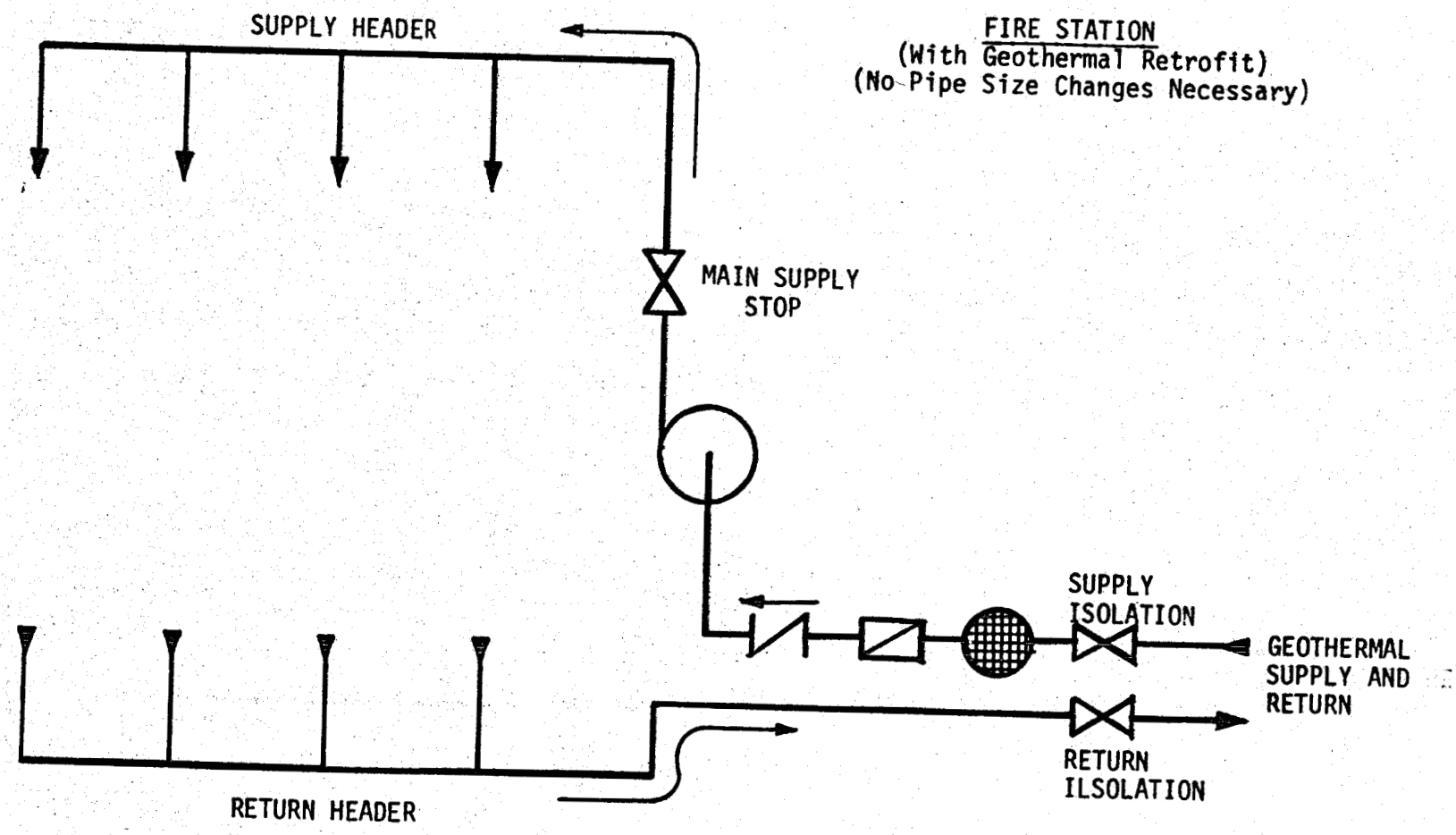
Estimated conversion costs

pump and materials	$300
labor	300
TOTAL	$600

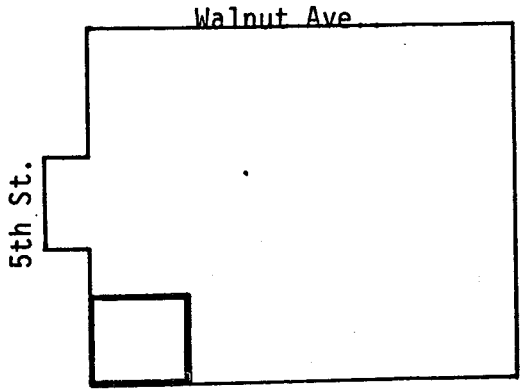
A desireable addition would be the installation of a thermostatically controlled control system. This could be as simple as two thermostat and control valves costing $300 or less to a more elaborate system at $600 or more. Modifications to the distribution system to allow individual room temperature control would also be desireable--estimated cost complete with controls is $3,500.



FIRE STATION
(Before Geothermal Retrofit)


SUPPLY HEADER
FIRE STATION
(With Geothermal Retrofit)
(No Pipe Size Changes Necessary)
MAIN SUPPLY
STOP
SUPPLY
ISOLATION
GEOTHERMAL
SUPPLY AND
RETURN
RETURN
ILSOLATION
RETURN HEADER

F. City Hall Conversion



KLAMATH FALLS CITY HALL

Est Heat Load 696,000 BTH
Est GPM 52 @ 165°F ΔT 20°

The building is constructed of brick with a built-up roof. There are two floors, each with approximately 2,900 square feet and a full basement which is only partially used.

The building was constructed in 1914 and parts of the interior have been remodeled several times over the years with interior walls moved and ceilings lowered. Plans are not available for any of the work--original or remodeling.

The present heating system was originally installed as a steam system and is now hot water. A gas fired water (695.8 MBH) heater located in the northwest corner of the basement supplies water at 200°F to 22 tube-type radiators throughout the building and to the Klamath Falls Police building next door.

Heat load estimations for the building were difficult since no construction details are available. Estimates based on information available indicate that for the building as a whole heat output from the radiators nearly matches heat loss at -10°F outside temperature; however, some rooms have more and some less than required. In particular the courtroom and coffee room on the second floor appear to be lacking heat output and would be cooler than desired at +10°F outside temperature. Enclosures on some radiators will reduce heat output somewhat but these rooms appear to have excess capacity and probably will remain warm enough. The heavy building construction has considerable heat storage capacity and deficiencies may not be noticed for short periods of -10°F weather unless wind velocities are high.

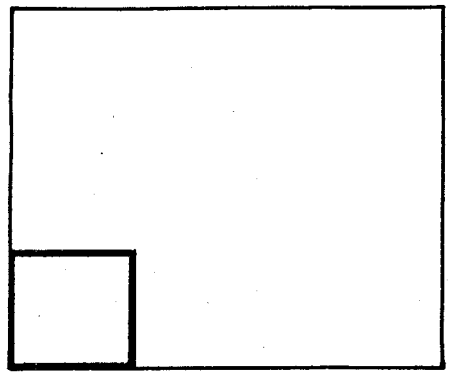
Assuming that a geothermal system with central heat exchanger will provide 52 gpm of 165°F water to the building and present pumps, radiators, and plumbing are utilized, the system will supply approximately 63 percent of the estimated peak heating load. This will provide sufficient heat for outside temperature of approximately 15°F above zero. Estimated cost of the mechanical room conversion is $3,000.

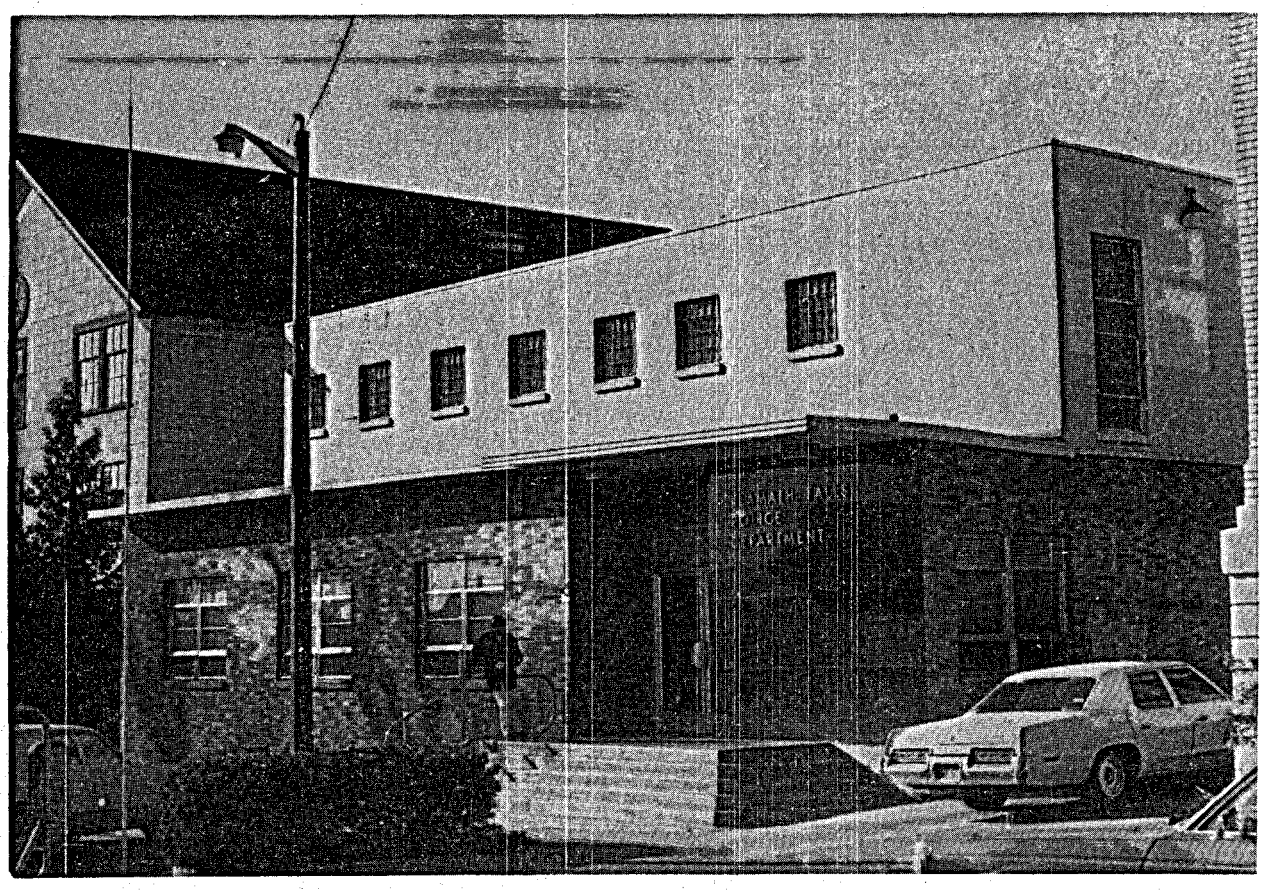
Estimated cost to convert the system to new wall convectors (1548 BTU/lin. ft.) 36 units each eight feet long--$16,480 including materials and labor, but not including engineering costs.

convectors	$16,480
control system--combined with police station	8,000
TOTAL	$24,480

G. City Police Station Conversion

Walnut Ave.





KLAMATH FALLS POLICE STATION

Est 281,500 BTH
16 gpm 35° ΔT all new
23 gpm 27° ΔT partially new

The building is two-story (second floor approximately two-thirds the size of first floor), brick and concrete construction. Total floor area is approximately 6,300 square feet.

According to available information and prints the first floor was originally heated by convectors in the office spaces and unit heaters in the locker and storage rooms. The second floor was heated by forced air (all the units were steam). In 1953 an additional unit for partial heating and cooling of the first floor was installed (also steam for heating). These were later converted to hot water operation, the water being supplied at about 190°F from the water heater in the City Hall which is adjacent. No information is available on the second floor system and any brand, model numbers, etc. are either missing or not accessible.

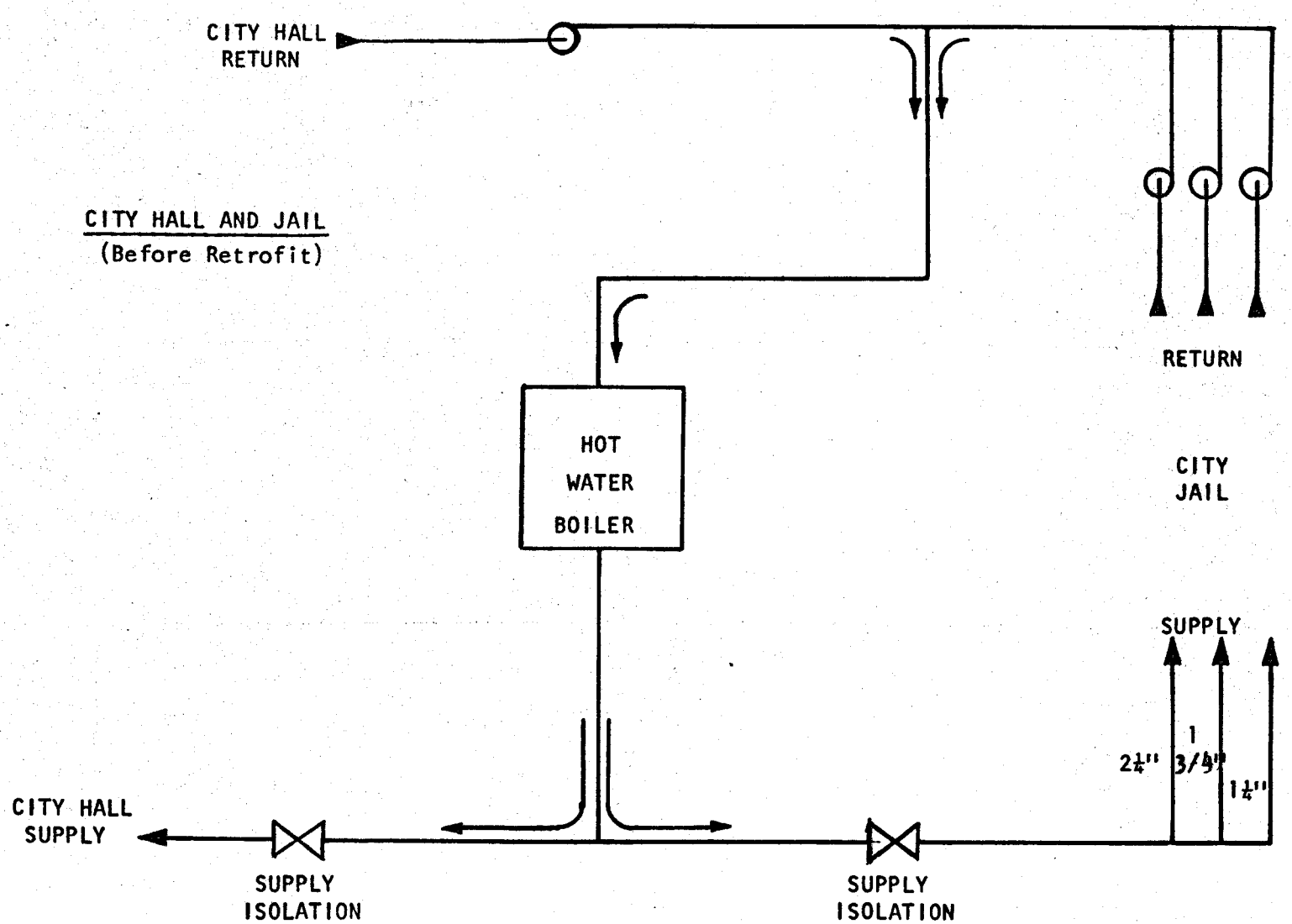
If the geothermal system supplies water at 165°F the present system will supply only about 55 percent of the required heat to the first floor. Since there is no information available about the second floor system, estimates are difficult to make. Based on observed size of the unit and outlet air temperature, the unit may supply from 75 to 100 percent of the requirements for the second floor.

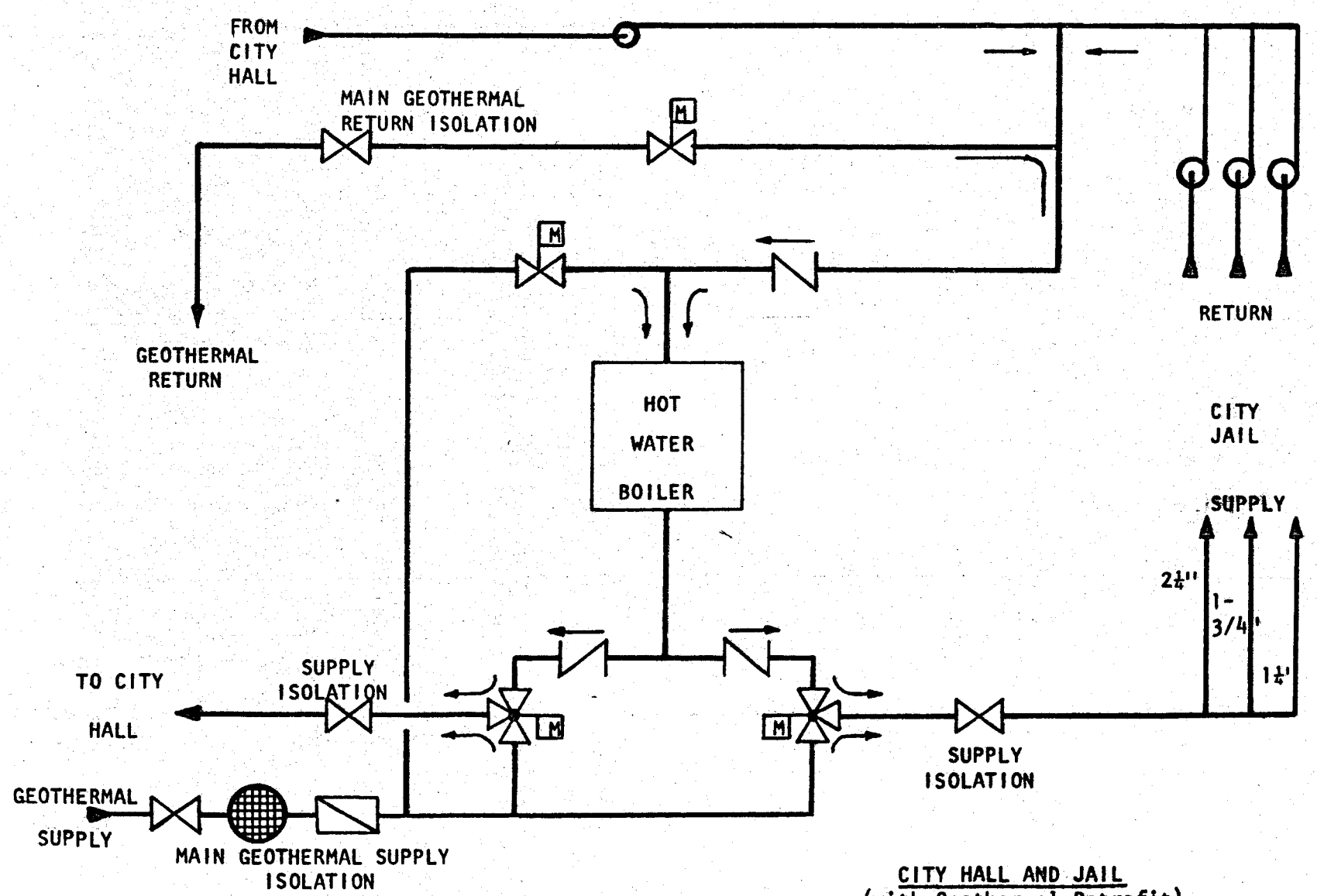
In order to supply 100 percent of the heat required for the building without peak heating it is recommended that new convectors be installed in the offices and new coils be installed in both forced air units. The present unit heaters should be adequate for the locker and storage rooms. The locker room has forced air outlets but the present system supplies very little heat. In order to maintain nearly similar flows and pressure drops the system should be designed for 35 to 40°ΔT.

Estimated conversion cost using the existing system is essentially zero since water would be supplied from the city hall except at a lower temperature. The system should be inspected and perhaps rebalanced. The cooling coils in the forced air unit for the first floor could be used for heating. Total cost should not exceed $650.

Estimated cost for new convectors and new coils in the forced air units is $3,220 including labor but not engineering and planning.

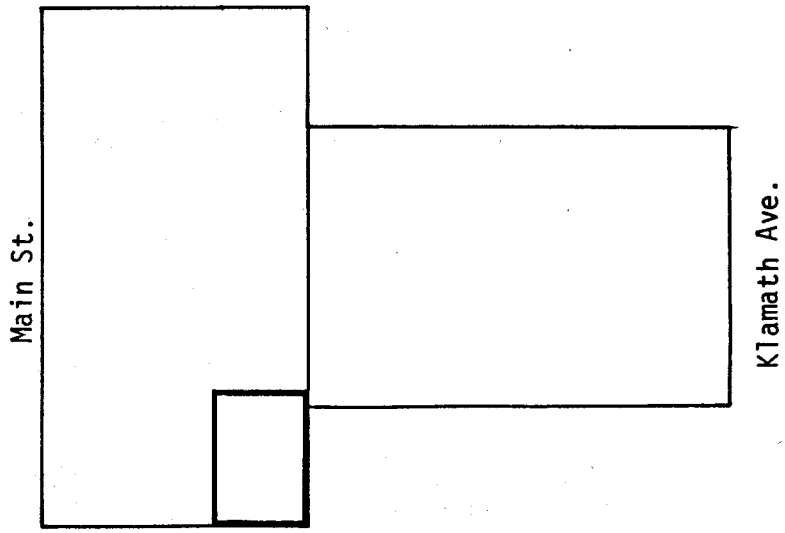
new convectors and forced air coils	$ 3,220
control system--combined with City Hall	5,000
TOTAL	$ 8,220

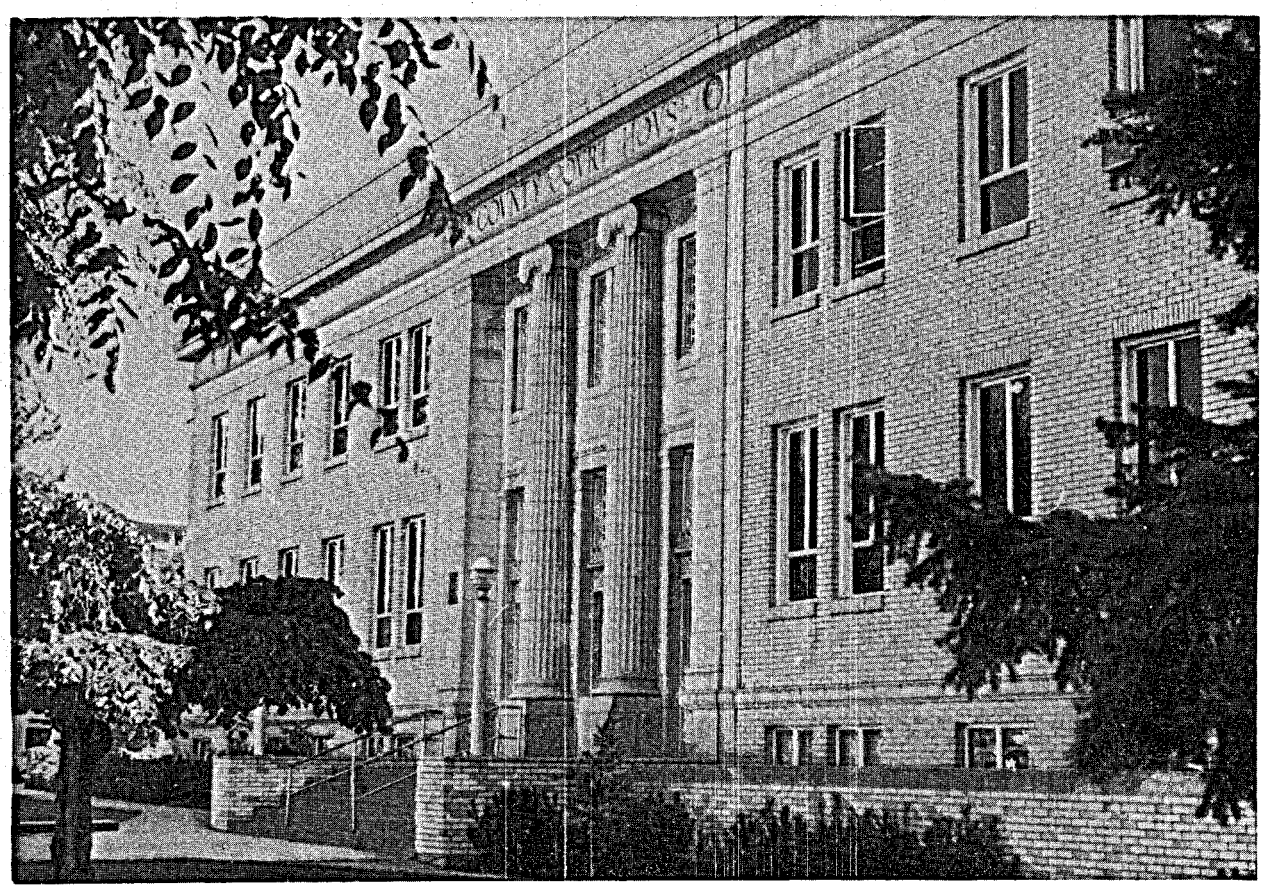

CITY HALL
RETURN
CITY HALL AND JAIL
(Before Retrofit)
RETURN
HOT
WATER
BOILER
CITY
JAIL
SUPPLY
2¼"
1
3/4"
1¼"
CITY HALL
SUPPLY
SUPPLY
ISOLATION
SUPPLY
ISOLATION



CITY HALL AND JAIL
(with Geothermal Retrofit)

H. Klamath County Court House Conversion





KLAMATH COUNTY COURTHOUSE

Est 1,280,000 BTH
80 gpm @ 165°F ΔT 32°

A four-story (including the basement) masonry building with approximately 24,960 square feet.

This building is presently having the second half of a new heating system installed. The first half of the system was installed last year. The building is being converted from steam heated cast iron radiator heat to water-forced air heating and cooling.

Thomas Sheet Metal, a local heating and air conditioning firm, has done detailed heat loss calculations and the new heating system design. Fan coil units for the first portion of the conversion were reported to have been designed based on 180°F entering water temperature and telephone conversations with the Airefco, Inc., the coil suppliers, indicate the units have the capacity to heat that portion of the building with 165°F entering water.

The second half of the conversion had the designs based on 165°F entering water in anticipation of the possible use of geothermal heating.

Heating coil specifications have not been made available so that OIT personnel could check the designs but based on the telephone conversations it is estimated that approximately 80 gpm of 165°F water will be required. The temperature drop across the coils is estimated to be 32°F.

The only modifications necessary for conversion to geothermal heat will be the plumbing to enter the building and to bypass the recently installed steam-water converter. The system will require balancing and checking operation at the geothermal water temperature. Estimated cost is $800.

balancing	$ 800
control system (shared with extension)	17,000
TOTAL	$17,800

COUNTY COURTHOUSE EXTENSION

Est Heat Loss 1,474,000 BTH
148 gpm @ 165°F ΔT 20°F

An extension added to the south side of the original courthouse building. Construction was lift slab with insulated curtain wall and nearly 50 percent glass.

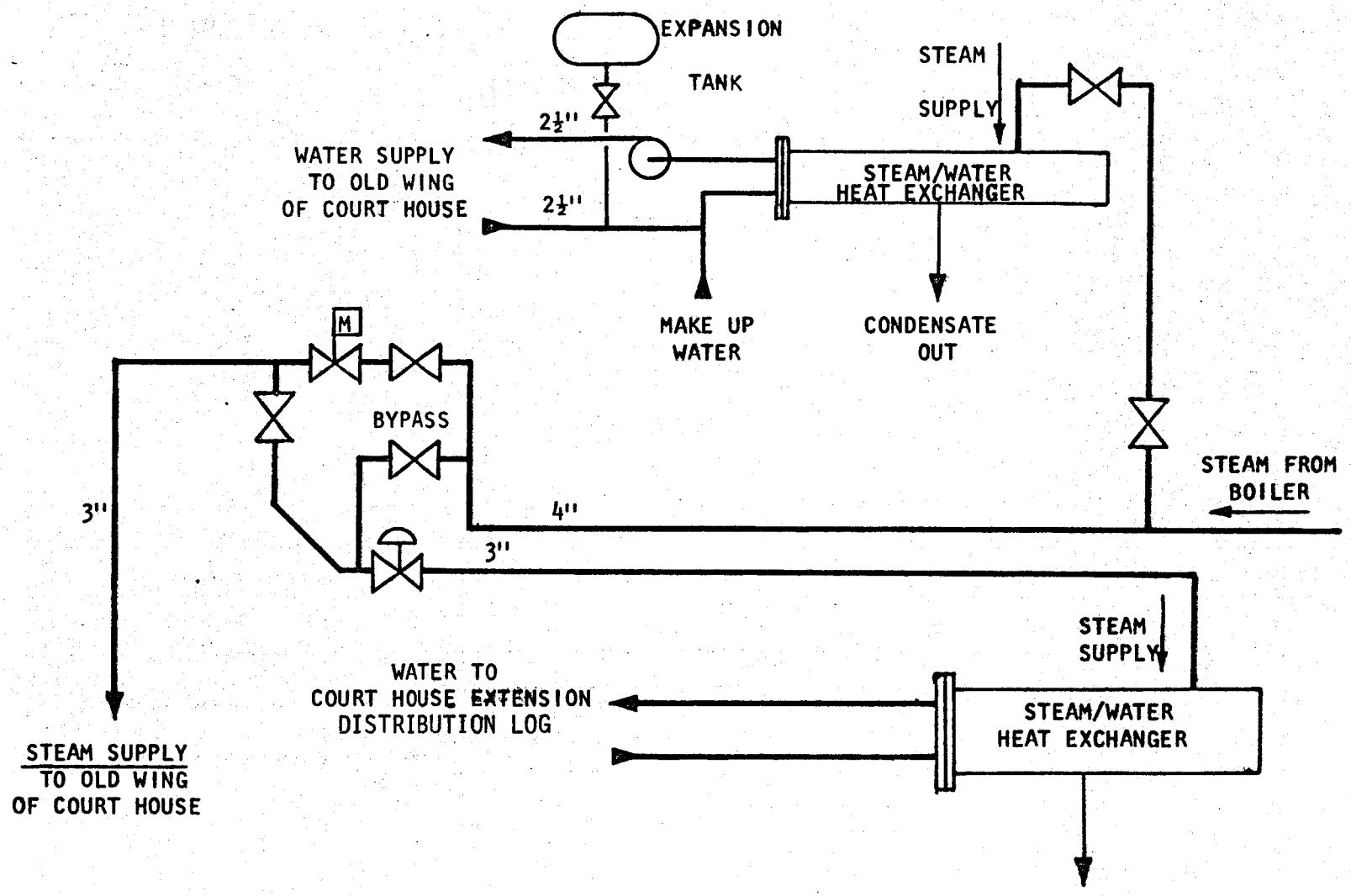
The heating system consists of individual forced air convector units along perimeter walls, forced air units in the hallways and courtroom on the fourth floor, and convectors in entrance foyers. All units are supplied with 200°F water from the main steam-water heat exchanger in the main courthouse. All units act as air conditioners in summer with chilled water supplied from a chiller in the courthouse.

When operating the unit conditioners on high fan speed with 165°F entering water temperature and ΔT of 13°F the units should provide 1.02 times the estimated peak heating load. The convectors and forced air units will provide about the same proportion of heat requirements for their respective areas but the ΔT is higher for these units. Therefore, with design flow rates the existing system should keep the building barely warm enough.

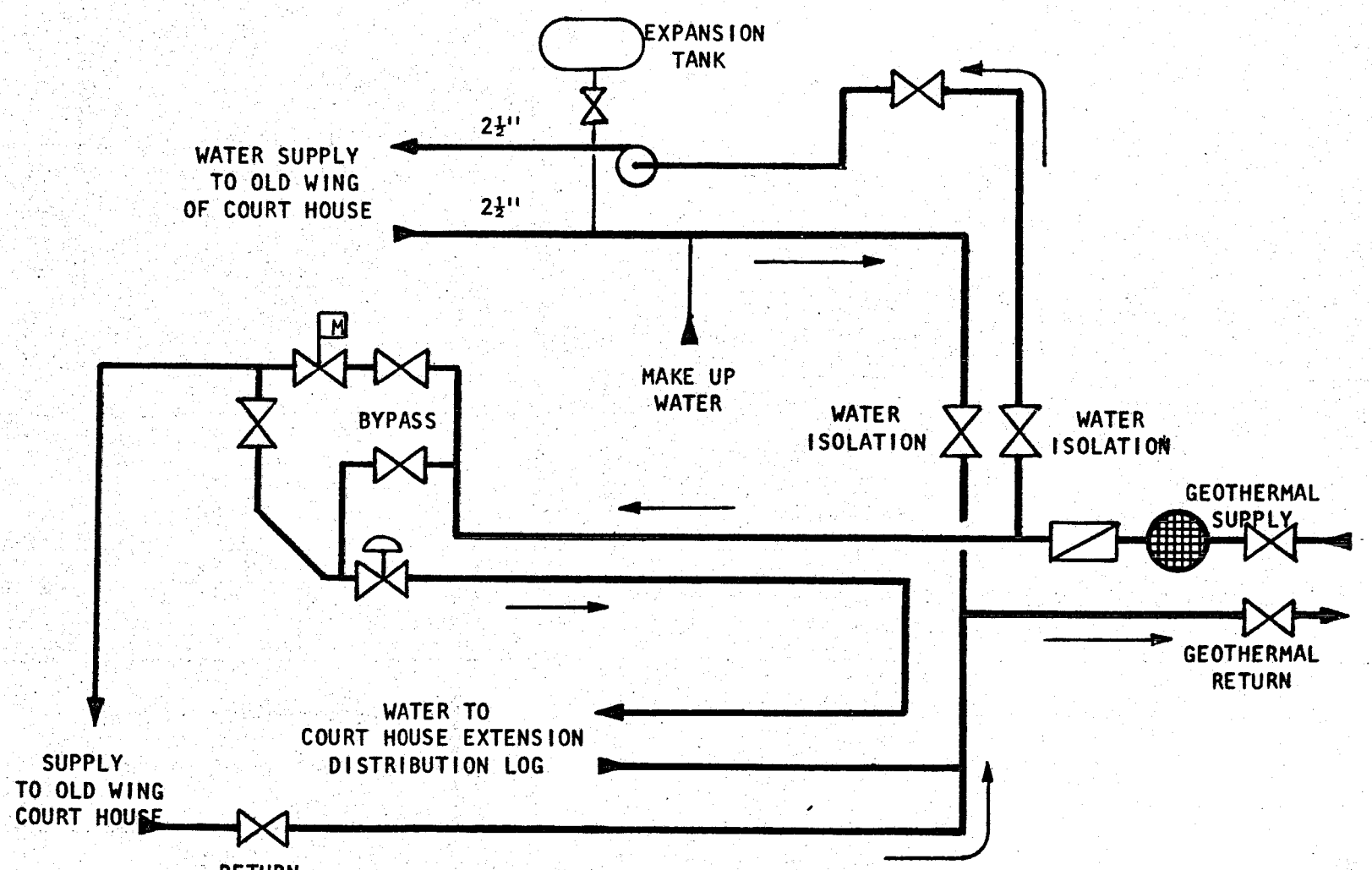
Several female workers have stated the building is cold with the present system. This could be due to faulty operation of the system or due to body radiation losses to the large window areas. This would be more noticeable by women than men since the women have more skin area exposed and tend to wear lighter weight clothing which increases radiation losses.

Since the heating capacity and the heat load are essentially equal, measures to reduce heat loss should be investigated, especially those that reduce radiation through the window areas.

The control system--mainly to control the operation of the valves and boiler--is included in the courthouse cost estimate.

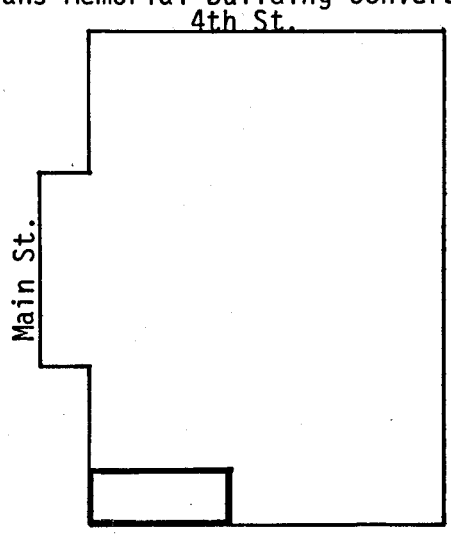


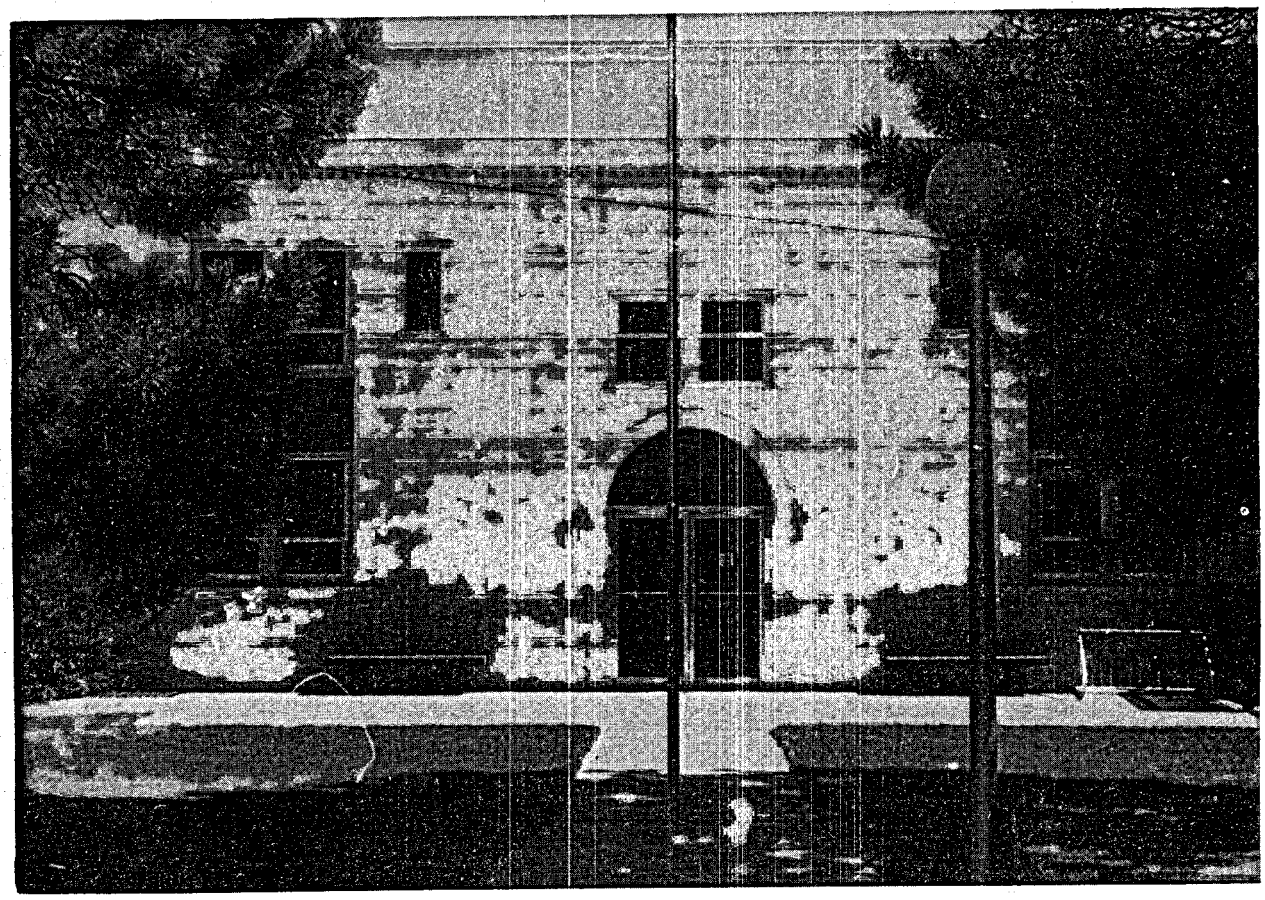
COURT HOUSE
(Before Retrofit)



COURT HOUSE
(with Geothermal Retrofit)

I. Veterans Memorial Building Conversion





VETERANS MEMORIAL BUILDING

Est heat load 527,000 BTH
Est requirements 34 gpm 31°F ΔT

The building is of masonry construction with built-up roof, two floors plus a partial basement with some storage and mechanical rooms. The building has been remodeled with dropped ceilings and has had a central forced air cooling system installed.

The building is presently heated with steam supplied from boilers in the courthouse.

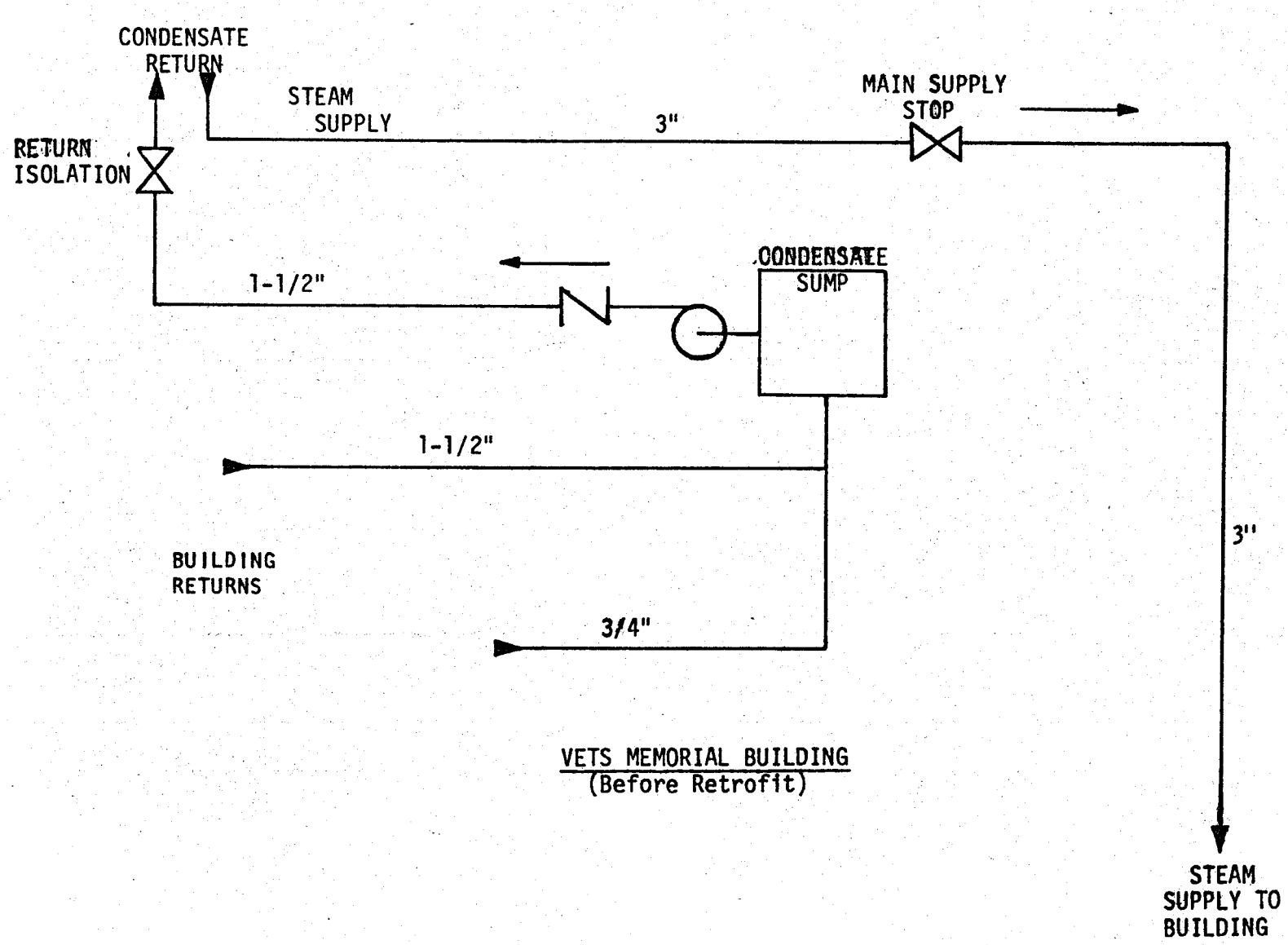
If the building is supplied with 165°F water from a geothermal system the present heating system will supply 53 percent of the required heat load with 34 gpm and exit water temperature of 148°F. The water from the present system could be routed through the existing cooling coils in the central forced air system to make up the remaining heat requirements. Three new zone pumps will be required.

The system should be provided with modulating controls to adjust system water temperature while maintaining constant air circulation. This would provide a very satisfactory conditioning system.

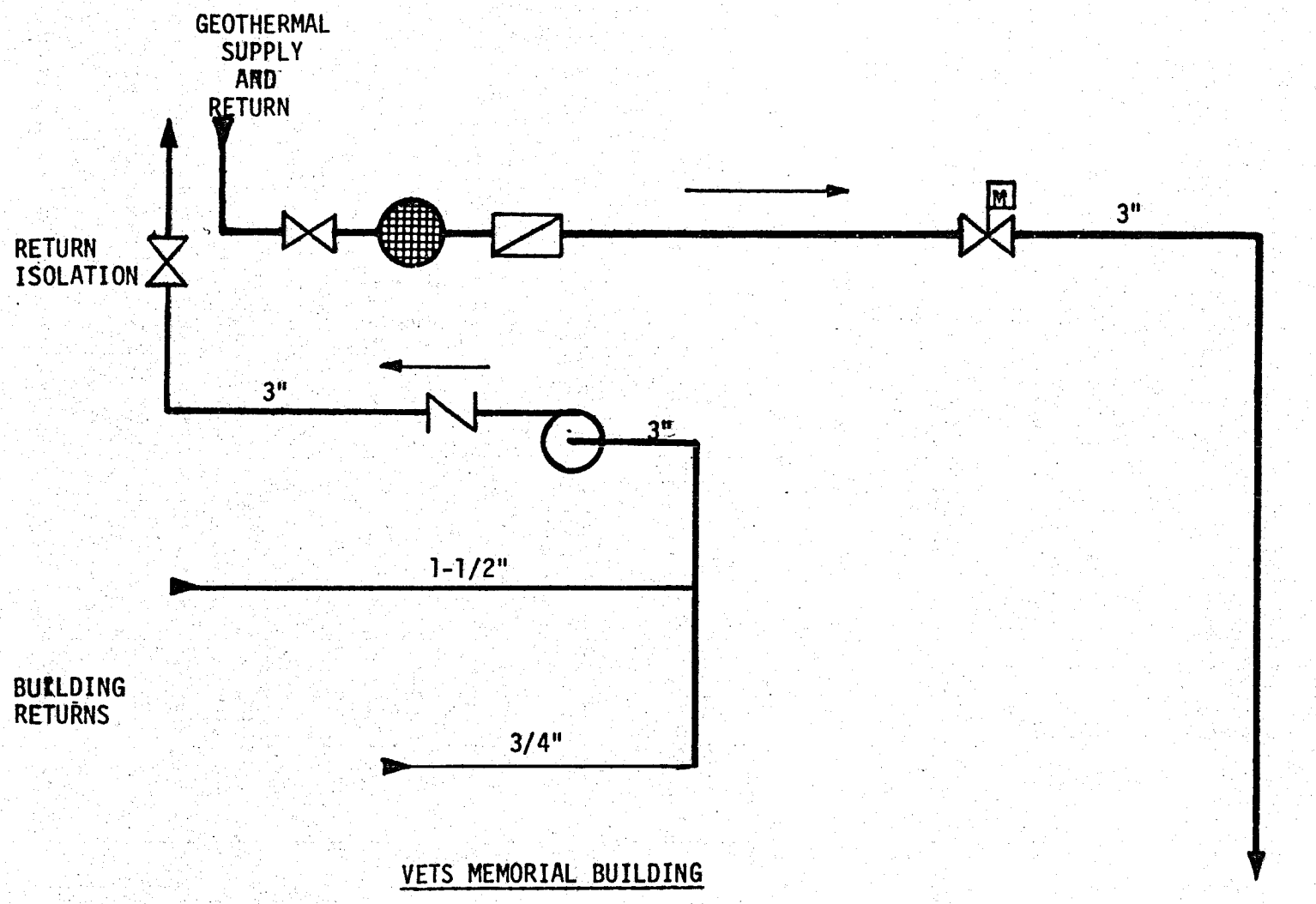
Estimated conversion costs

plumbing modifications, materials	$ 2,700
plumbing modifications, labor	1,600
*control system	12,000
TOTAL	$16,300

*New automatic control system interconnected to main courthouse controls.



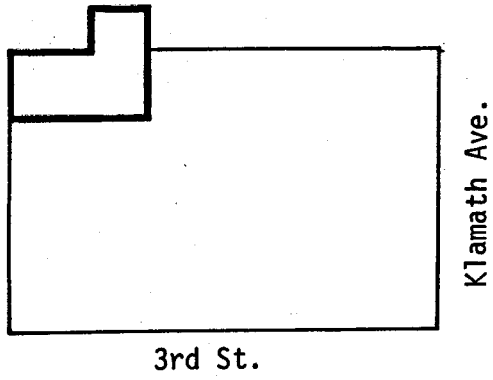
VETS MEMORIAL BUILDING
(Before Retrofit)

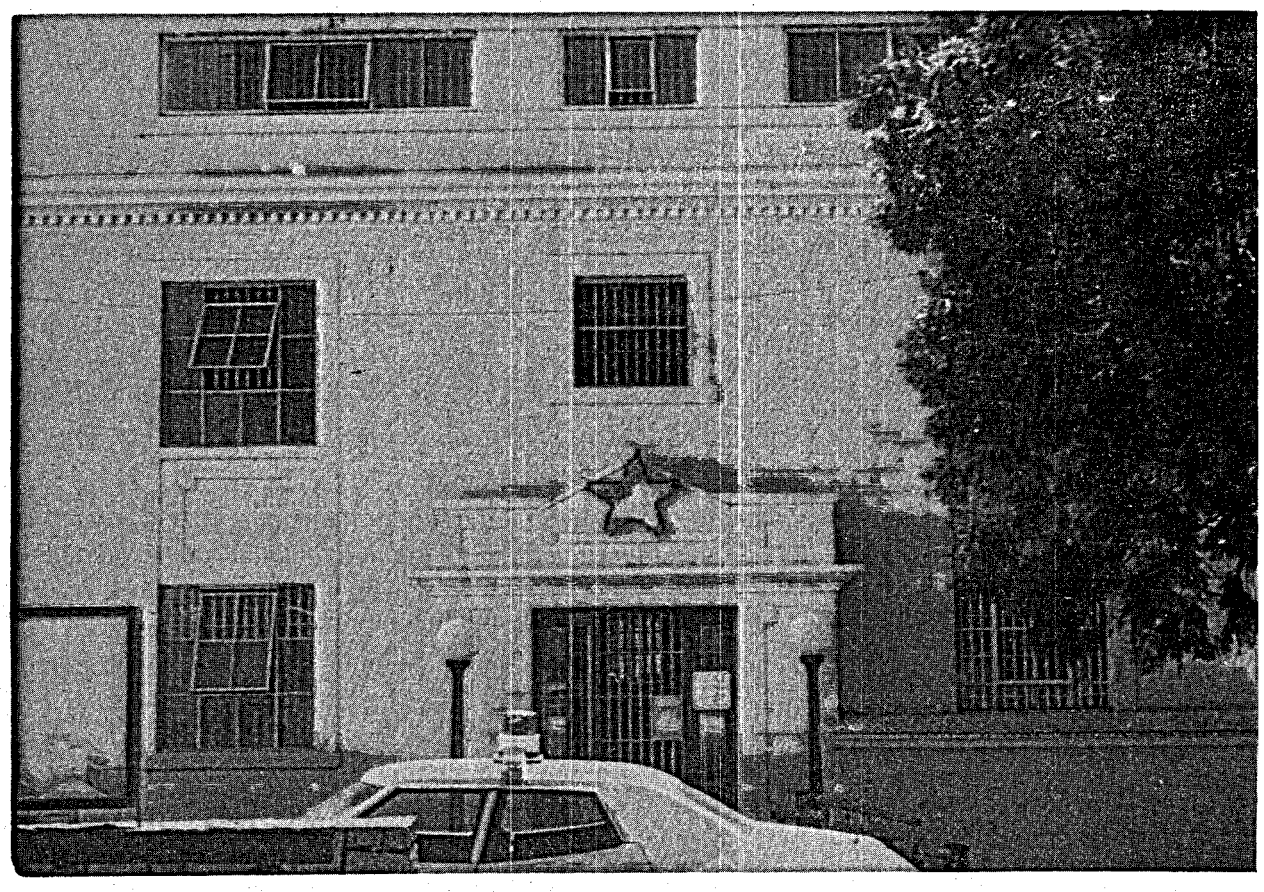


VETS MEMORIAL BUILDING

(With Geothermal Retrofit)
(And Necessary Pipe Size Changes)

J. Klamath County Jail Conversion





KLAMATH COUNTY JAIL

Est Heat Loss 590,350 BTH
Est gpm 59 @ 165° EWT ΔT 20°F

A three-story concrete structure. The original jail, built in 1927, was two-story, with the third floor addition in 1957. There is approximately 2,960 square feet per floor.

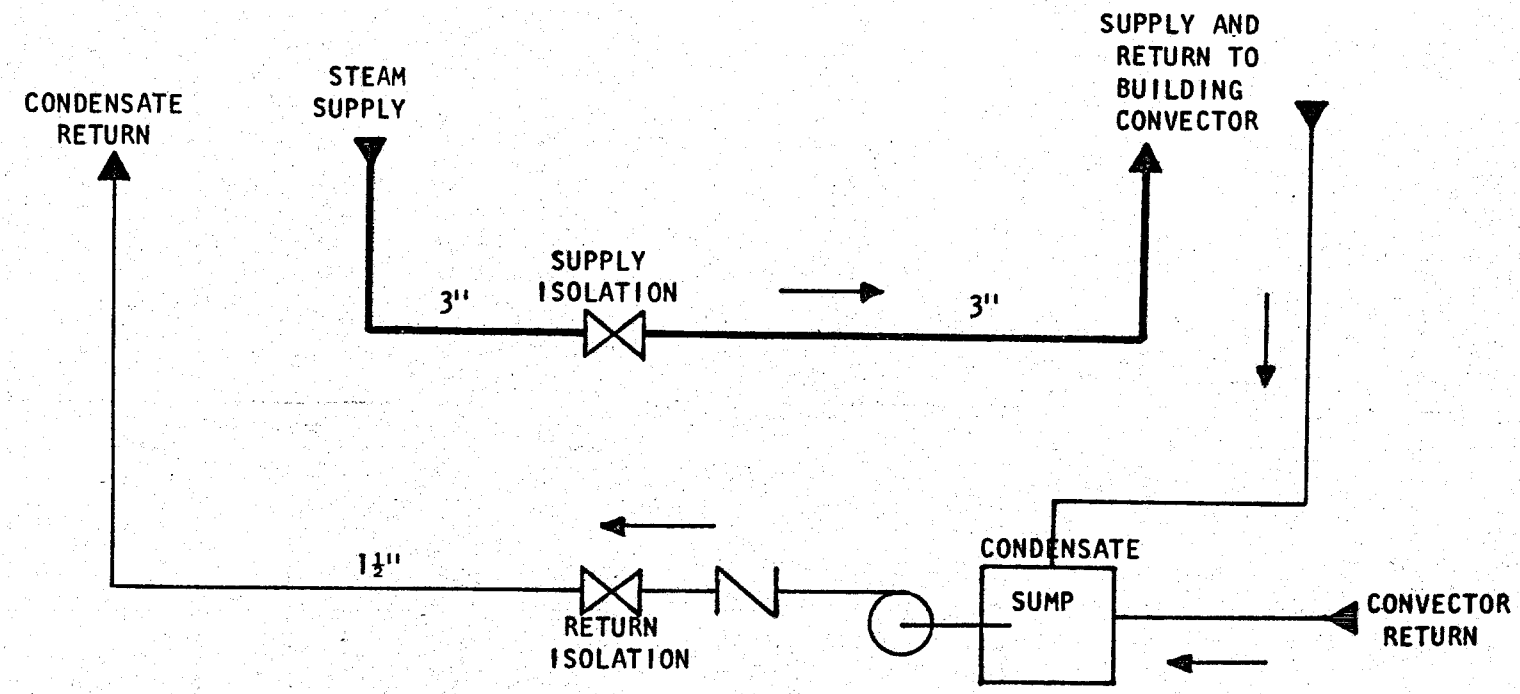
The building is heated by steam supplied from the boilers in the county courthouse. The first and second floor have the original cast iron radiators, and the third floor has fin tube convectors. The estimated heat output of 543,000 is less than the estimated requirements at -10°F outside temperature. If the geothermal system supplies water at 165°F the system will provide approximately 53 percent of the required heat.

In order to provide the required heat the radiators and fin tube convectors must be replaced with higher output units.

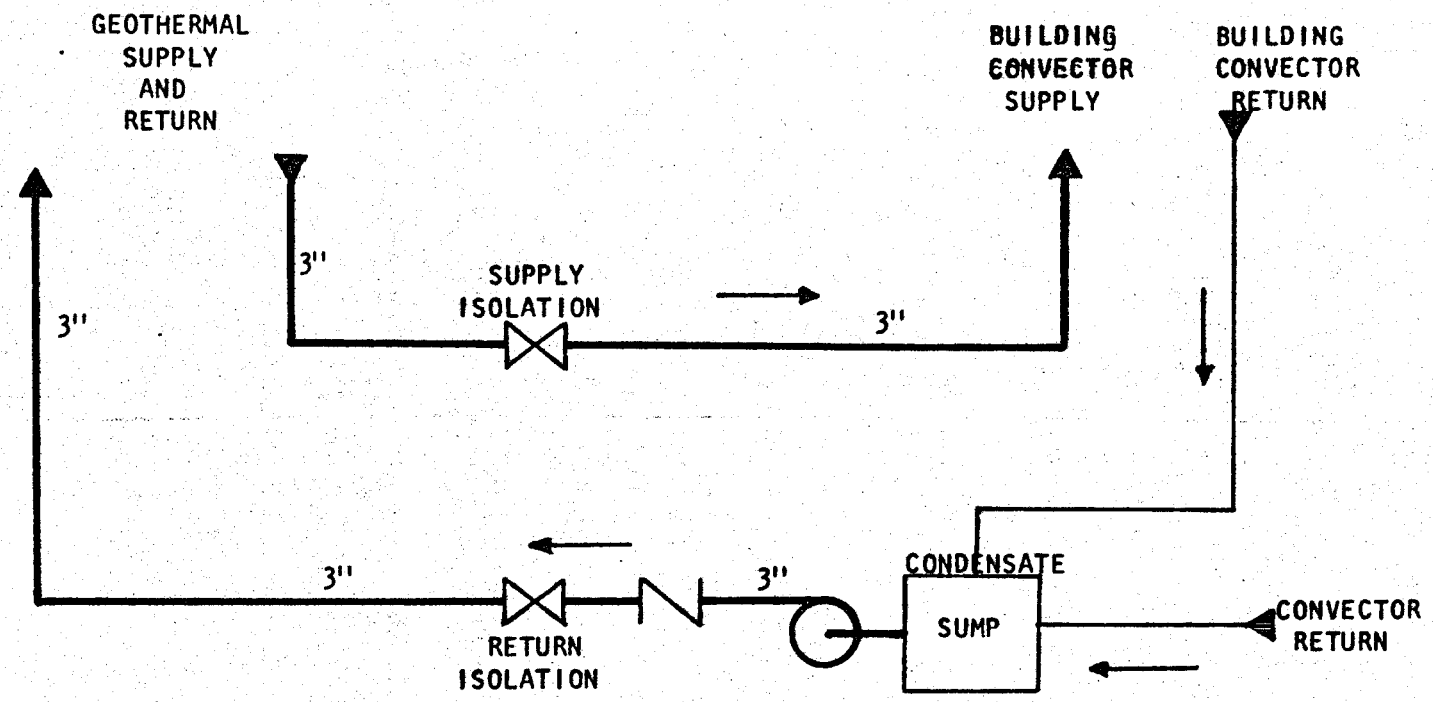
Estimated conversion costs

convectors (382 feet total)	$ 6,200
pump	300
*controls	10,540
labor and miscellaneous (convector and pump)	4,160
TOTAL	$21,200

*New automatic control system interconnected to main courthouse control system.

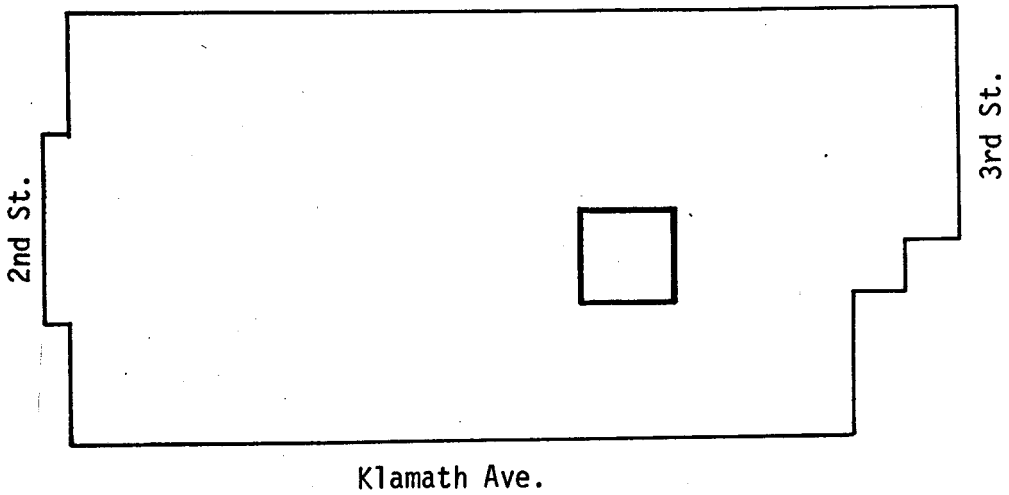


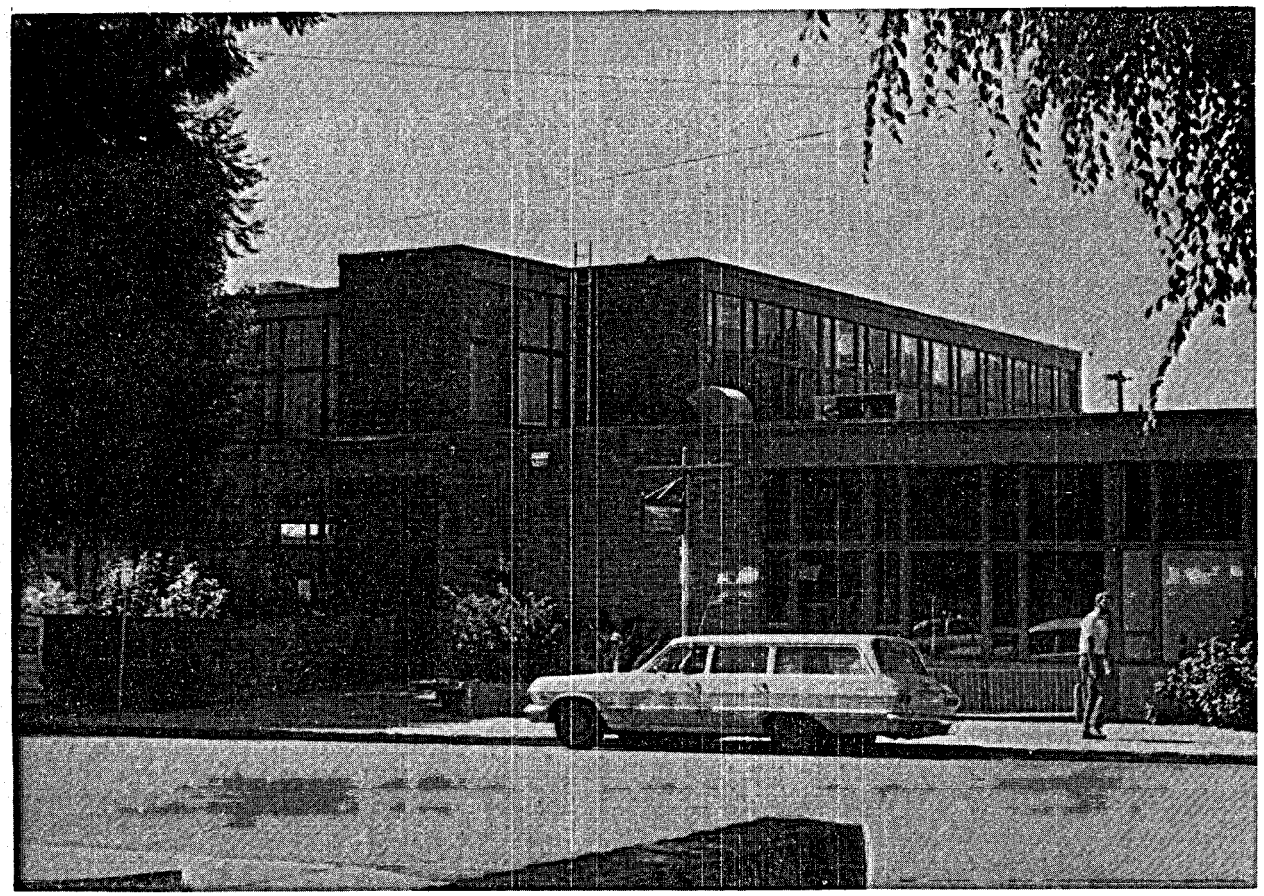
COUNTY JAIL
(Before Retrofit)



COUNTY JAIL
(with Geothermal Retrofit)
(And necessary pipe size changes)

K. Klamath County Library Conversion





KLAMATH CITY-COUNTY LIBRARY

Est 1,783,000 BTH
90 gpm @ 165 ΔT 40°F

The building is constructed of brick--approximately 20,000 square feet of single story constructed in 1974 and approximately 7,800 square feet two-story constructed in the late 1950s. Plans are available for remodeling of the two-story portion in 1969 and constructing the one-story portion in 1974. Plans for the original construction are not available.

The building has two heating systems. The two-story portion system consists of a steam-to-water converter, three forced air units, and floor-type finned tube convectors. The system is outside air temperature modulated and appears to have been designed for about a 200°F EWT with 30° ΔT. No records of exactly what equipment was installed have been found.

The single story new portion also has a steam-to-water converter, five forced air units and four unit heaters. Specifications indicate the forced air coils are to operate at 200°F maximum EWT with maximum ΔT of 60°F. The unit heaters are to operate at 200°F maximum with 14.5 ΔT. This system is also outside air temperature modulated.

Recommended conversions:

New Portion (1974)

The five forced air units on the roof for the new portion should provide 95 to 100 percent of the required heat load at -10°F and these units could remain as is since the building has considerable heat holding capacity and long periods of continuous -10°F weather are rare. The four unit heaters (one in loading area and three under floor) will provide only about 30 percent of the required heat and must be replaced. Estimated cost is $1,200 including labor.

Old Portion

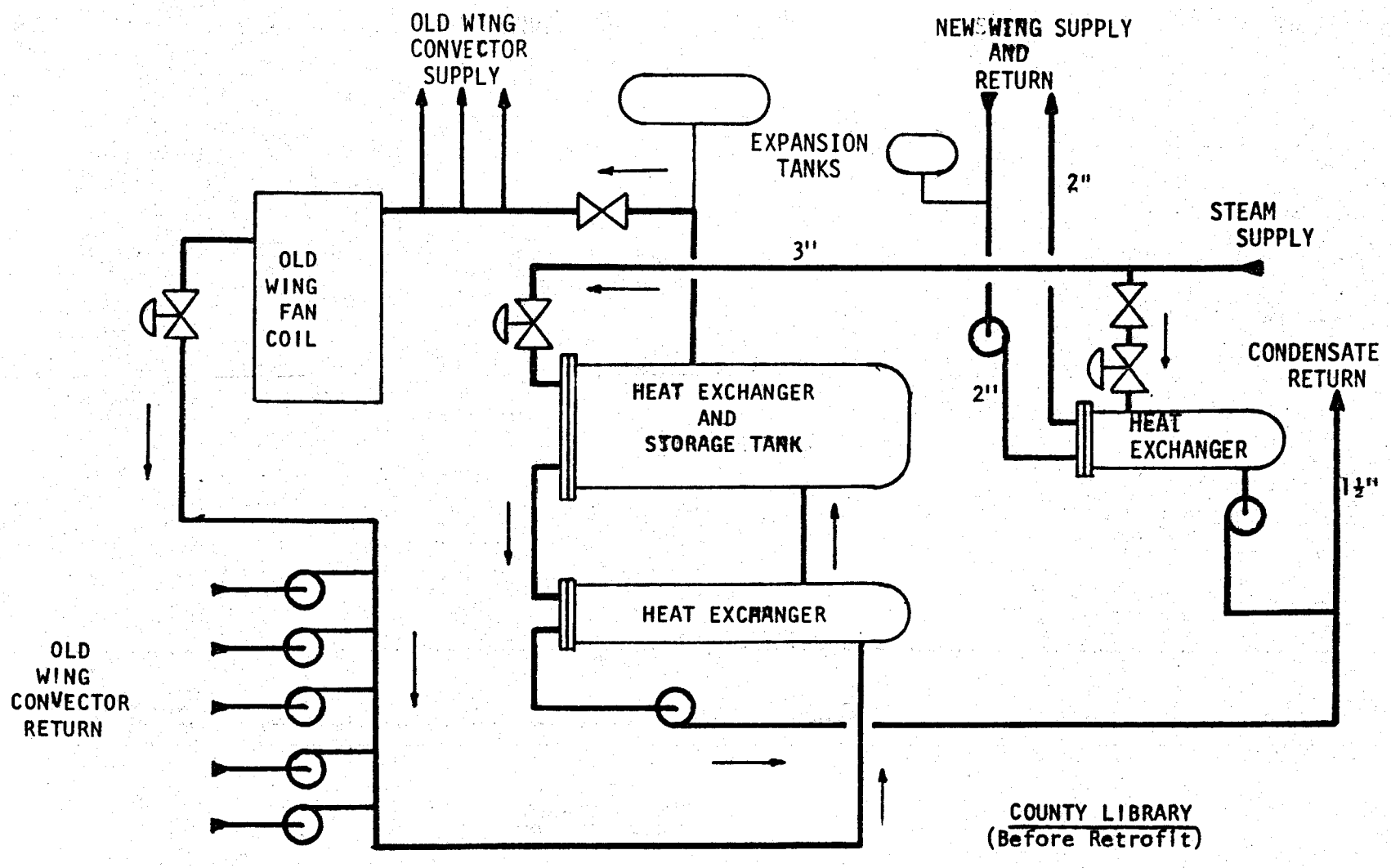
The three forced air units should provide about 65 percent of the required heat and should be replaced. The head librarian's office is now much too cool and must receive more heat. Estimated cost is $1,250 including labor.

The floor-type convectors on the second floor should provide adequate heat. They now have about 30 percent more capacity than required.

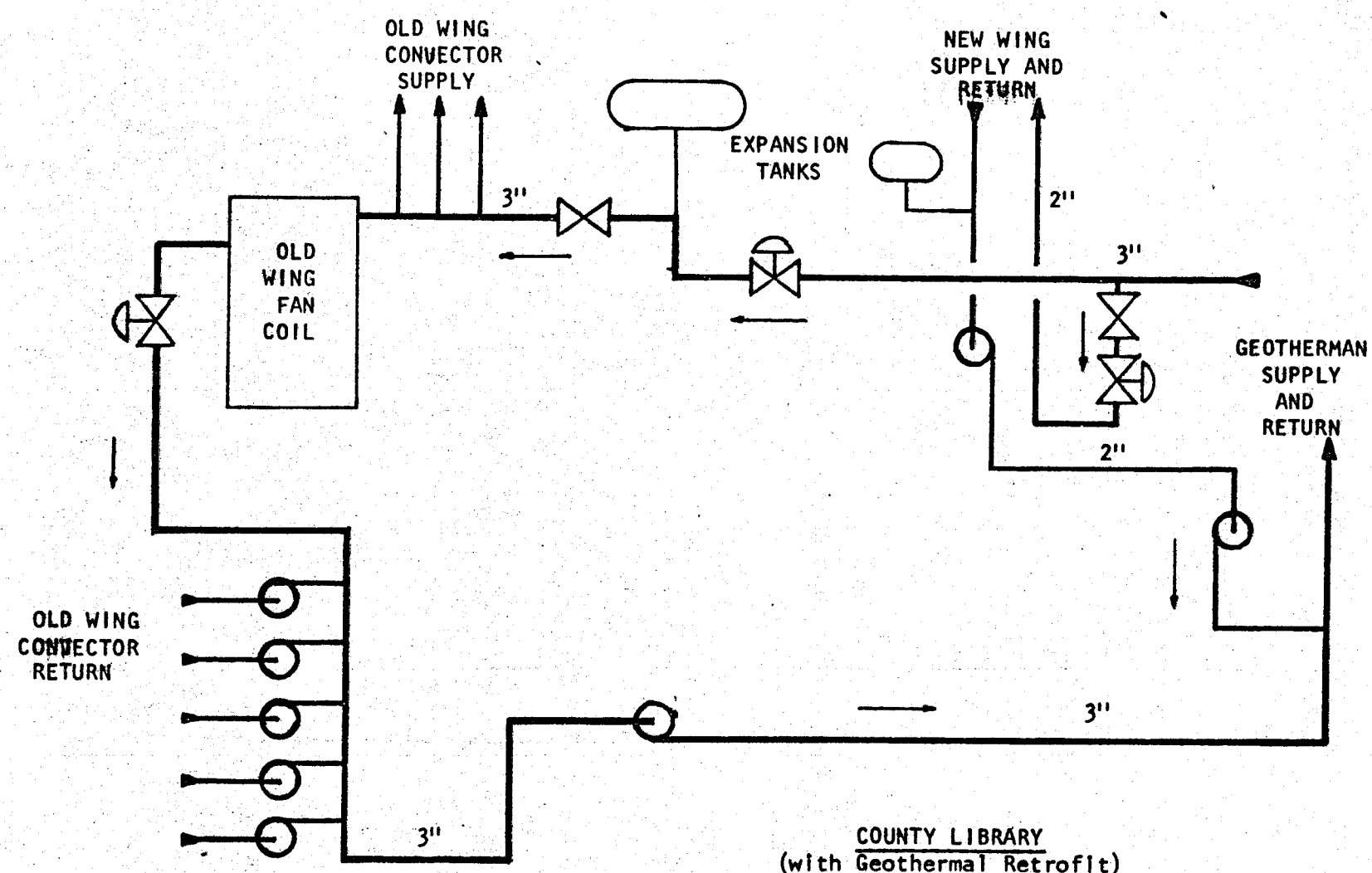
Mechanical room plumbing, valves, etc., for geothermal system $2,000 including labor.

Automatic control system to coordinate with courthouse controls and boilers $15,050.

Total estimated conversion cost $19,500 excluding engineering.

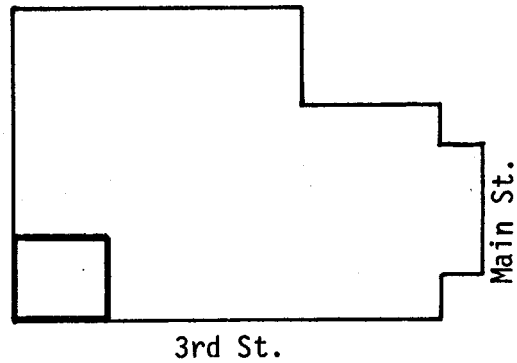


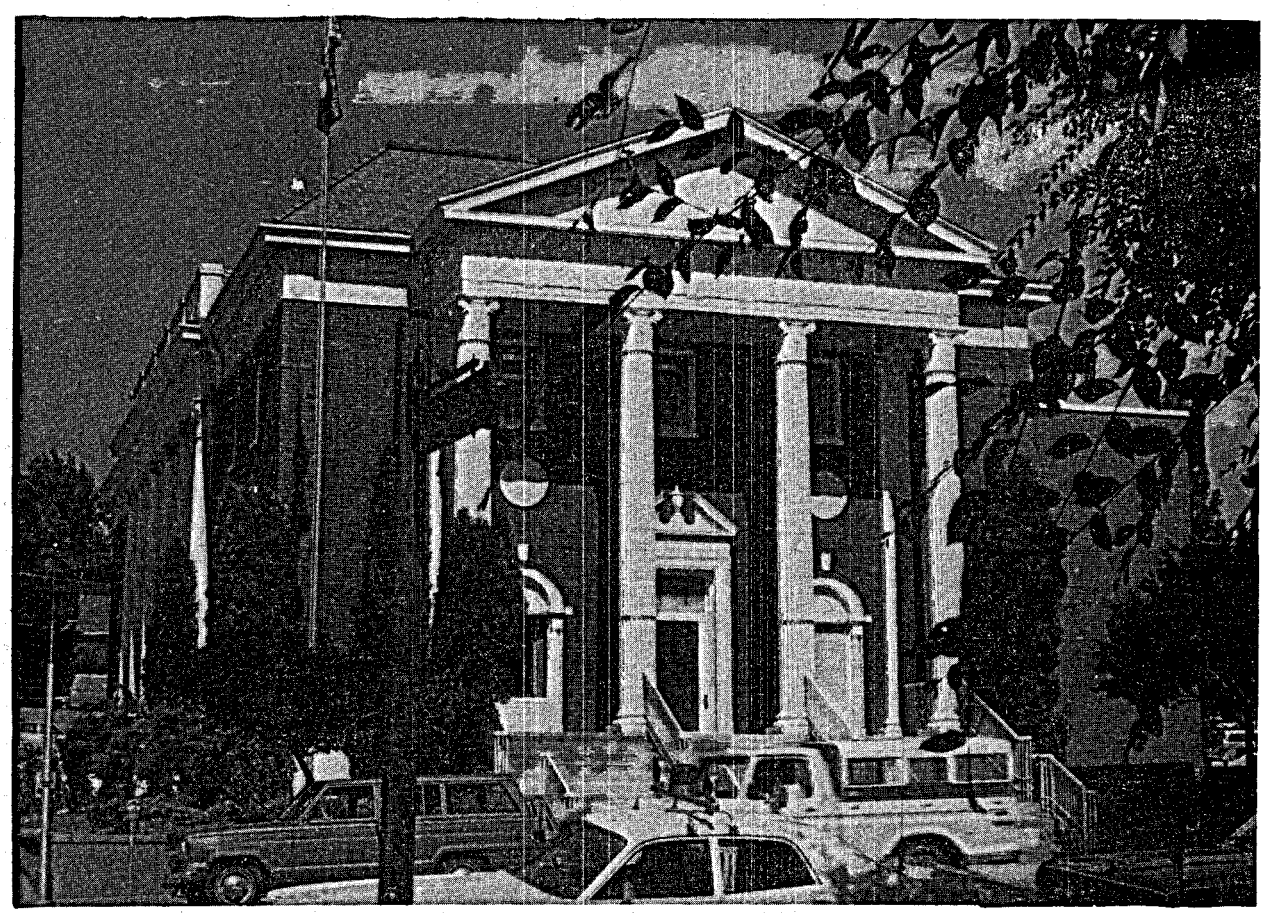
COUNTY LIBRARY
(Before Retrofit)



COUNTY LIBRARY
(with Geothermal Retrofit)
(Plus necessary Pipe sizes)

L. Klamath County Court House Annex Conversion





COUNTY COURTHOUSE ANNEX
(Old Elks Lodge)

Est 418,200 BTH

The building is constructed of brick and has recently been remodeled to serve as the courthouse annex. Plans for the remodeling are available but not exactly "as built".

A completely new heating system has been installed. The present system consists of a 502 MBH gas fired water heater, 12 heat pump AC units, 7 convectors, and 4 unit heaters with associated outside temperature monitoring controls.

Present water requirements

66.4 gpm - 80°F - 12.52 ΔT for heat pumps

3.74 gpm - 190°F - 20° ΔT for convectors (in foyers and stair wells)

4.3 gpm - 180°F - 20° ΔT for unit heaters (in basement)

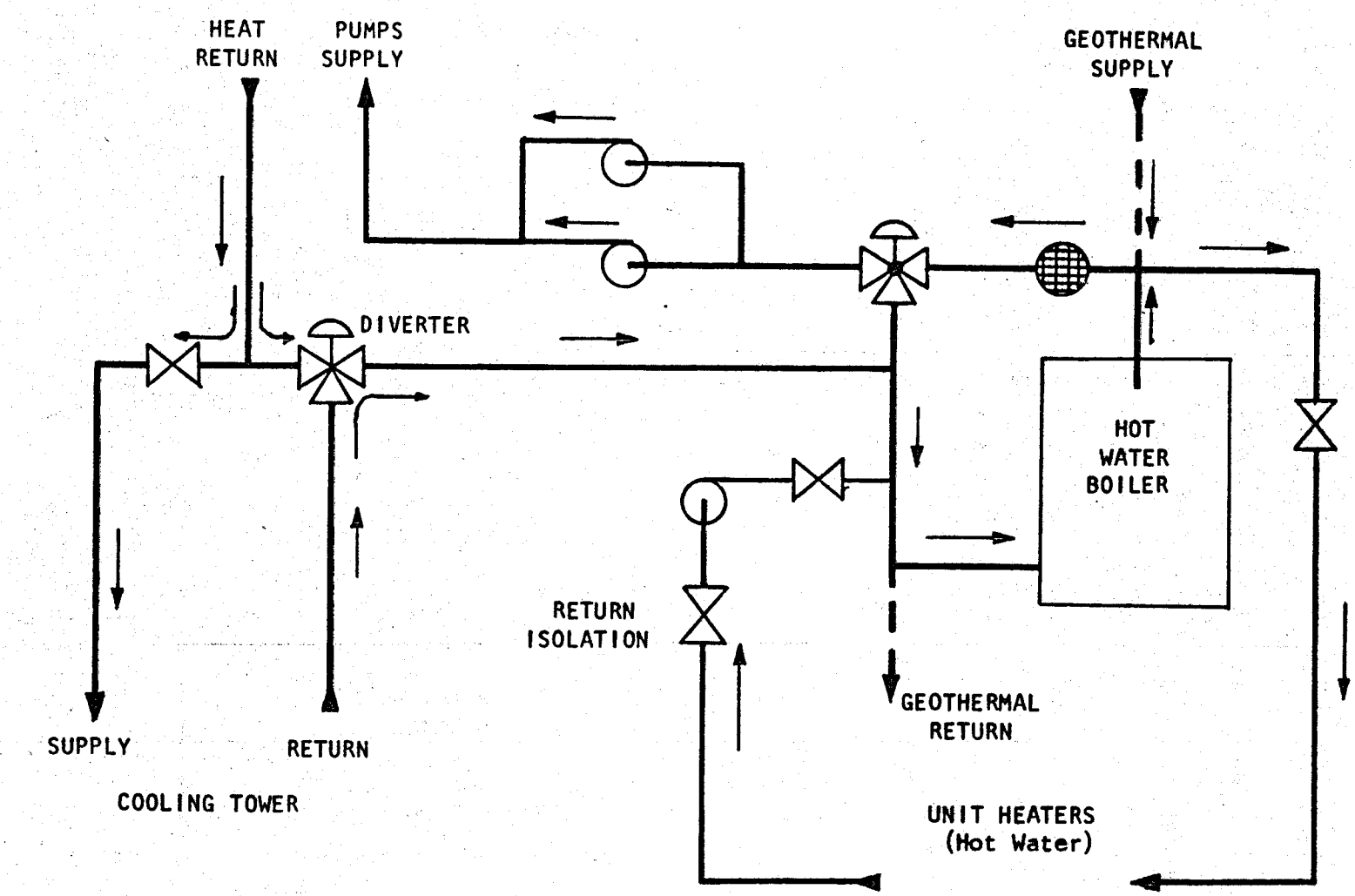
In the present system water at approximately 200°F from the heater ("boiler") is mixed with water returning from the system to maintain the required supply water temperatures, i.e., 80, 180, 190°F.

In order to obtain a larger temperature drop and thus make the geothermal system more efficient, the annex heat pumps could utilize water discharged from the courthouse complex across the street. The existing mixing valves will operate satisfactorily for this purpose. A separate low temperature supply line would supply water to the heat pump water distribution system.

The convectors and unit heaters must be supplied with 165°F water by a high temperature supply line directly from the main plate-type exchanger in the courthouse. At 165°F the existing units will supply only about 53 percent of the required heat. The most economical retrofit will be to install four new unit heaters in the basement and install additional rows of fin tubes in the convector units. Existing piping and pumps are sufficient to handle the increased flow since the flows are very small.

Estimated costs

mechanical room	$1,500
unit heaters (including plumbing)	800
convector modifications	1,000
TOTAL	$3,300



COURT HOUSE ANNEX
(with Geothermal Retrofit)

VIII. ECONOMICS

The economics of a utility system becomes more attractive with an increasing load factor until the system reaches full capacity use. Presented in this section is the economic outlook for the base plan (ten public buildings), including future expansion to 12 public buildings and for the expanded plan for 110 buildings (each like one of the ten buildings in the base plan) in the business district, equivalent to and including the 12. When taking advantage of low cost geothermal energy the developer must determine whether this incentive justifies investment in a geothermal system near a resource. In arriving at this determination he must trade off energy (fossil fuels) cost savings against such considerations as drilling, supply and distribution costs, retrofit costs, labor and community response.

The results of the cost analysis for the various project sizes of the study are shown in Tables 4, 4A and 4B and Figure 14. The ten-building plan includes a system that allows a second phase expansion to 12 buildings with the addition of the post office and one future public building.

The third project level analysis is based on a separate main supply system and snow removal grid along Main Street. In addition to supplying the 12 buildings by means of the base plan distribution system, future heat load and customers can be added along the route up to 5000 gpm total geothermal water flow. This flow could serve the central business district (from Eleventh to Fourth Streets) equivalent to a heat load of 110 buildings like the ten buildings of the study project. The main 16-inch line would supply geothermal fluid from approximately eight wells in addition to the museum well, located in the Old Fort Road area. The number of wells required depends directly on the total flow at the maximum heating demand. Each well was assumed to support a nominal 500 to 600 gallon per minute pumping rate and was estimated to cost $45,000. This cost is for a drilled and cased depth of 1500 feet. The return pipeline would service a Main Street snow removal grid. Capitalization costs and annual costs based on a 25-year retirement for the three projects are summarized in Table 4 for comparisons. The energy equivalents and values of the geothermal energy for the three project sizes are summarized in Table 6.

The geothermal costs per therm for the 10, 12 and 110 buildings are $.265, $.197 and $.148 per therm, respectively. For comparison the most recent cost of heating the ten buildings with natural gas during 1976 was $.251 per therm, $.344 per therm with oil and $.440 per therm with electricity. The capital investment on the geothermal system could be payed off in 12.3 years using the expenditures on fossil fuels (natural gas) to heat the ten buildings, based on 1976 rates. A geothermal system also provides an insurance against inflation of fossil fuel heating.

TABLE 4

COST COMPARISONS

Item	Project Option Capital Costs		
	Base Plan 10 Buildings	Base Plan 12 Buildings	Expanded Plan 110 Buildings
1. Wells	$ 35,000	$ 35,000	$ 540,000
2. Delivery Pumping, Controls & Pump House	36,400	36,400	291,000
3. Installed Delivery System	137,900	144,500	333,900
4. Installed Snow Removal Grid	--	--	188,000
5. Heat Exchangers	14,600	16,300	16,300*
5a. Post Office Heat Exchanger	--	4,400	4,400*
6. Building Conversion (Retrofit)	133,000	150,000	150,000*
6a. Post Office Conversion	--	17,000	17,000*
Subtotal	$ 356,900	$ 403,600	$1,540,600
7. Engineering Costs @ 12%	42,800	48,400	184,900
8. Project Contengencies @ 20%	71,400	96,900	308,100
TOTAL	$ 471,100	$ 548,900	$2,033,600
	Annual Costs		
1. Delivery Costs (Pumping)	$ 2,030	$ 2,030	$ 16,300
2. Amortized Cost of Capital (25-year retirement at no interest)	18,840	21,960	81,340
3. Maintenance Allowance	4,500	5,000	19,000
4. Total Cost (per year basis)	$ 25,370	$ 28,990	$ 116,640
5. Effects of Interest @ 7% (25-year retirement)	21,670	25,250	174,900
TOTAL COST PER YEAR	$ 47,040	$ 54,240	$ 291,540
Annual Cost Per Therm	$ 0.265	$ 0.197	$ 0.148

*Includes heat exchangers and conversion for 12 public buildings only.

TABLE 4A

GEOTHERMAL WELL OPTIONS

Option	Use of Existing Wells		New Wells Required		Cost of Drilling and Casing
	Production	Reinjection	Production	Reinjection	
10 buildings	1 @ 1235*	1 @ 260**	0	1 @ 1200†	$ 35,000
12 buildings	1 @ 1235*	1 @ 260**	0	1 @ 1200†	35,000
Expanded System	1 @ 1235*	1 @ 260**	8 @ 1500'†† (@ $45,000 ea.)	4 @ 1500'†††	540,000

*Museum well
**Fire station well
†Vicinity of Klamath and Broad Streets
††Old Fort Road Area
†††Vicinity of Old Fort Road

TABLE 4B

APPROXIMATE COST OF UNDERGROUND PIPE

Size in.	Length ft.	Transite Non-insulated Class 150 $/ft.	Temp-Tite Insulated Class 150 $/ft.	Installed Total Cost* Non-Insulated Supply	Installed Total Cost* Insulated Supply
3	1050-S		9		-
4	1050-R	2	--	$ 10,400	$ 18,500
4 (post office)	300	2	13	3,000	6,600
8	4100-S 3550-R	4	18	56,200	119,400
14	9700	9	40	266,800	597,500
16	9700	11	50	309,400	725,600
Base Plan (12 buildings)				66,600	144,500
Expanded Plan (110 buildings)				333,900	725,600

*Ten percent added for fittings, anchors and access areas.

TABLE 5

BUILDING CONVERSION COSTS
BUILDING SUPPLY WATER TEMPERATURE = 165°F

Building	Heat Load Peak BTU/Hr x 10^6	% Peak With Existing Convectors	Cost of Additional Convectors (100% PK)	Cost of Conversion	Total
Museum	1.430	57	$ 6,500	$ 10,500	$ 17,000
Fire Station	0.529	100	--	4,100	4,100
City Hall	0.696	63	16,480	13,000	32,700
City Police Station	0.282	55	3,220		
Courthouse	1.280	100	--	17,800	17,800
Courthouse Ext.	1.474	100	--		
Veterans Memorial	0.527	100	--	16,300	16,300
County Jail	0.590	53	6,200	15,000	21,200
Library	1.783	65	2,450	17,050	19,500
Courthouse Annex	0.418	95	1,800	2,500	4,300
TOTALS	9.01	79	$ 34,850	$ 96,250	$133,000

TABLE 6

ENERGY UTILIZATION AND SAVINGS

Buildings	Therms/yr	Value of Natural Gas in 1976 @ $.251/therm	Equivalent BBLs of oil	Value of Electricity in 1976 @ $.015/KWhr
BASE PLAN				
Three City	29,400	$ 7,400	525	$ 12,900
Seven County	148,000	37,100	2,640	65,100
Subtotal (10 buildings)	177,400	$ 44,500	3,165	$ 78,000
Future Public Building	39,400 (est.)	9,900	700	77,300
Post Office	59,100 (est.)	14,800	1,060	26,000
TOTAL (12 buildings)	275,900	$ 69,300	4,930	$121,300
EXPANDED PLAN				
110 Equiv. Buildings	1,970,000	$494,000	35,200	$866,800

A cost comparison was developed to include escalation of natural gas and amortization of the capital investment on the geothermal system over a 25-year period. Starting with 1976 as a dollar base, natural gas prices were escalated at a 7 percent per year rate through ten years. Since natural gas supplies and usage may be restricted within the next ten years, the escalation was not carried beyond 1987. Beyond 1987 it is assumed some form of synthetic gas will be required or conversion to some other form of fossil fuel heating, such as coal.

The annual capitalization figure for the geothermal system was developed using a 7 percent interest rate (typical of present municipal bonds), and included delivery costs, maintenance allowance and fossil fuel peaking costs. Figure 14 illustrates a comparison between natural gas escalation and the three geothermal project sizes.

IX. ENVIRONMENTAL CONSIDERATIONS

The use of a geothermal resource for space heating is generally regarded by environmental groups as a positive action provided care is taken in planning the development, utilization and disposal of the fluid.

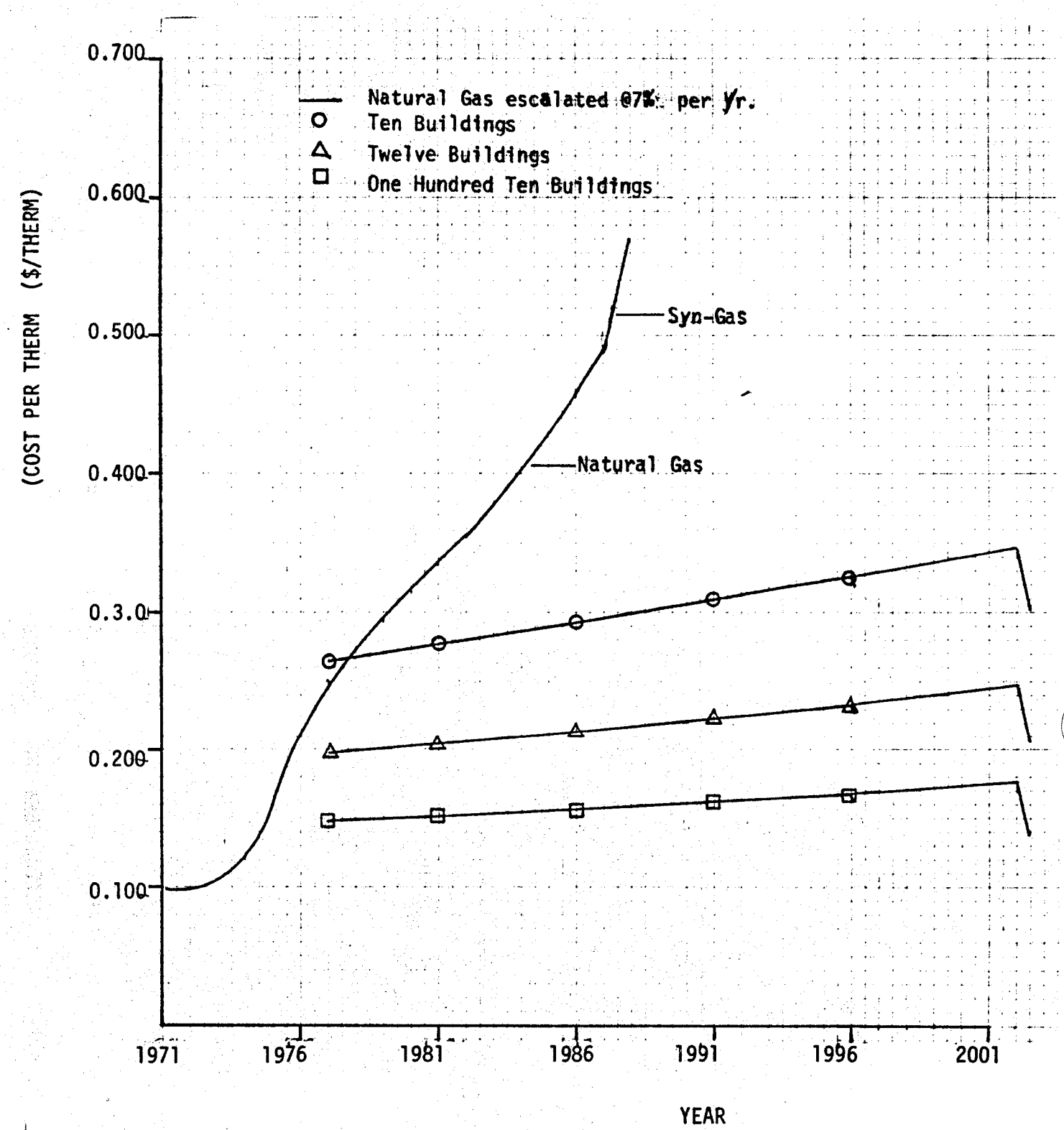
The several phases of geothermal development may effect various environments, either due to physical alterations or discharge of pollutants. These stages of geothermal development are: 1) extraction; 2) energy conversion (fluid transmission and heat extraction for direct use); and 3) waste disposal. The major cause of physical-biological development is related to the following:

A. Fluid Extraction-Reservior Effects

Precipitation is the source of most ground water in the Klamath Basin. Polar Pacific winter air masses account for the greatest contribution of moisture in the basin, with most of the precipitation occurring in the higher elevations. The Klamath Falls station reports a mean annual precipitation of 14.3 inches, while in the higher elevations at Crater Lake it is 60 inches. Most of the surface water in the vicinity of Klamath Falls is derived from three streams: Sprague River, Williamson River and Wood River. A significant amount of water also enters Upper Klamath Lake from springs and seeps in or near the lake and from small tributaries on its periphery. It is estimated the total water collected in the basin from all the above sources is 3,100,000 acre feet per year (1.01×10^{12} gallons/year). The annual outflow to the Klamath River is 1,205,000 acre feet at the Keno station. The total geothermal fluid pumped and from artesian wells in

FIGURE 14

COST COMPARISONS FOR NATURAL GAS
AND THE THREE GEOTHERMAL PROJECT SIZES



Klamath Falls is estimated at 5.0 x 10^8 gallons per year (2000 tpm is the peak use). This represents 0.1 percent of the total annual flow of water into the basin. There appears to be a significant recharge of the subsurface ground water by means of percolation of meteroic waters through the extensive fracture zones in the basin. The waters are heated as they percolate downward by the higher than normal temperature gradient in the basin and rise as they encounter the deep range front faults. The geologic environment of the vertical fracture zones is primarily of consolidated rocks, fractured lava flows and pyroclastic material. Due to the nature of this geologic environment there appears to be no concern for the effects of subsidence as the geothermal fluids are extracted.

B. Energy Conversion

Depending on the project size selected, the direct environmental benefits will be a reduction in the general level of air pollutants in downtown Klamath Falls. Although these benefits would be small for the base plan, the reduction could be significant for the expanded plan to 110 equivalent buildings: 3,000 pounds of particulates, 118 pounds of sulfur oxides, 3,900 pounds of carbon monoxide, 1,580 pounds of hydrocarbons and 23,600 pounds of Nitrogen Oxides per year (USEPA, 1974).

Surface disturbance would be minimal for the base plan, since the main line is confined to the alley between Klamath and Walnut Avenues.

C. Waste Disposal

The disposal of geothermal fluids is a dual consideration--one of surface discharge and one of reinjection.

The fluid as well as the heat should be considered a resource. It is implicit that "disposal" is considered only after the resource is no longer "useful". If the water is pure enough to be desired by an irrigation district, for instance, then discharge of the water into canals is considered a use of the geothermal fluid, not disposal of it.

Surface disposal may be considered if:

1. The fluid is of low salinity (<1000 ppm). The total dissolved solids (TDS) for the museum well is 924 ppm.

2. The spent fluid is cool (<100°F). The estimated temperature of discharged water from the buildings is 145°F; therefore, further use or cooling would be required for surface discharge.

3. The discharge reservoir (lake, pond, stream or canal) capacity or flow greatly exceeds the geothermal fluid flow. It would be necessary for city storm drains to handle the discharge from the county buildings, which are already accepting geothermal fluids from approximately 45 artesian and pumped wells in addition to surface runoff.

4. The natural recharge capability of the geothermal reservoir is approximately the same as the rate that fluids are being withdrawn. Indications are that in Klamath Falls the recharge greatly exceeds the withdrawal, since in pumped wells water levels have remained essentially the same for years, with exception of seasonal variations.

Reinjection of the fluid into wells is generally the preferred mode of disposal. This involves technical and funding problems concerning the number and location of wells, the necessity for pumps, and the monitoring of the process for induced seismic activity, etc. In general, a well will accept as much water (due to a hydrostatic head) as can be pumped. The depth and location of reinjection wells are another concern. The following five approaches have been suggested or employed (Howard, 1975).

1. Reinjection into the same strata, but sufficiently "upstream" from the production wells to allow for natural heating of the water in the transit distance.

2. Reinjection in the same strata but "downstream" from the production wells. This method allows for the maintenance of fluid pressure but does not require that nature reheat the reinjected fluid for later withdrawl from production wells.

3. Reinjection at a lesser depth than the production wells, at the top of the reservoir, with little lateral displacement between wells.

4. Reinjection at a greater depth than the production wells. This method is perhaps more attractive than (3) above, because the deep wells need only be about half the number of shallower wells.

5. Reinjection into an entirely different strata and reservoir. One must be certain the strata is not in close communication with a domestic water aquifer. This approach probably creates more geological-hydrological complexities than either of the four preceding methods.

The fire station well accepting discharge fluid of 182 gpm from heat exchanger No. 3 is similar to (4) above, while the main reinjection well located at Klamath Avenue and Broad Street is similar to (2) above.

The advantages of reinjection are: it helps to maintain fluid pressure in producing reservior, prevents subsidence, and eliminates surface disposal concerns.

Disadvantages are: costs of disposal wells, possible need for reinjection pumps, possibility of cooling producing reservoir, and possibility of chemical deposition blocking the pores of the formation in the reinjection region of the well.

Ground water rights will need to be established with the State of Oregon Water Resources Department (SWRD) for the pumped fluids. The same department is responsible for ground water recharge into the discharge well. Final rules and regulations governing recharge wells have not been completed but it is evident at this time that: 1) the recharge will need to be injected into the same aquifer from which the fluids were removed; and 2) the extraction and reinjection wells will need to satisfy SWRD requirements in regards to casing and routing to insure the integrity of other aquifers which may have been penetrated during the drilling processes.

X. REFERENCES

1. ASHRAE Handbook of Fundamentals, Chapter 20, "Design Heat Transmission Coefficients," American Society of Heating, Retrofitting and Air Conditioning Engineers, Inc., New York, 1972.

2. Boldizsar, T., "Geothermal Use in Hungary," Proceedings of the International Conference on Geothermal Energy for Industrial, Agricultural and Commercial-Residential Uses, Klamath Falls, Oregon, October, 1974.

3. Burrows, William, "Utilization of Geothermal Energy in Rotorua, New Zealand," Proceedings of the International Conference on Geothermal Energy for Industrial, Agricultural and Commercial-Residential Uses, Klamath Falls, Oregon, October, 1974.

4. Eckert, E.R.G. and Robert M. Drake, Jr., Heat and Mass Transfer, Chapter 3, "Steady Heat Conduction," McGraw-Hill Book Company, New York, 1959.

5. Howard, J.H. (ed.), Present Status and Future Prospects for Nonelectrical Uses of Geothermal Resources, Lawrence Livermore Laboratory, Livermore, California, October, 1975.

6. Lund, John W., G. Gene Culver and Larsen S. Svanevik, "Utilization of Geothermal Energy in Klamath Falls," Proceedings of the International Conference on Geothermal Energy for Industrial, Agricultural and Commercial-Residential Uses, Klamath Falls, Oregon, October, 1974.

7. Sammel, Edward, Hydrologic Reconnaissance of the Geothermal Area Near Klamath Falls, Oregon, Open File Report, Menlo Park, California, 1976.

8. Schmitt, R.C., L.E. Donovan, S.G. Spencer, J.G. Keller and R.C. Stoker, Project Summary for the Boise Space Heating Project, Idaho National Engineering Laboratory, Idaho Falls, Idaho, April, 1976.

9. State Water Resources Board, Klamath Basin, Salem, Oregon, June, 1971.

10. USEPA, Compilation of Air Pollutant Emission Factors, Research Triangle Park, July, 1974.

11. Zoega, Johannes, "The Reykjavik Municipal District Heating System," Proceedings of the International Conference on Geo-Thermal Energy for Industrial, Agricultural and Commercial-Residential Uses, Klamath Falls, Oregon, October, 1974.

APPENDIX A

STUDY PROPOSAL

BOARD OF COUNTY COMMISSIONERS

KLAMATH COUNTY OREGON

COUNTY COURTHOUSE -:- KLAMATH FALLS, OREGON 97601

February 9, 1976

Paul J. Lienau
Geo-Heat Utilization Center
Oregon Institute of Technology
Klamath Falls, OR 97601

Gentlemen:

Your letter of January 27, 1976 was presented to us by Mr. Earl Kessler with your recommendation of a feasibility study on Klamath County's geothermal well.

Please use this letter as a formal request by this Commission to employ the team of Paul J. Lienau, Gene Culver and John Lund to perform the feasibility study for Klamath County.

As you gentlemen are aware, funds for this project must go through the budgetary proceedings; however, funds could be made available by July 1, 1976. If it would be convenient for you to commence your work sooner than this, an Agreement could be executed to facilitate your time, but payment would have to be made after July 1, 1976.

We would like to express our gratitude for the opportunity to cooperate with O.I.T. in such a worthwhile project.

Sincerely yours,

BOARD OF COUNTY COMMISSIONERS

Raymond P. Thorne
Chairman of the Board

Bryant Williams
County Commissioner

Lloyd Gift
County Commissioner

CONCEPTUAL DESIGN/FEASIBILITY STUDY

FOR

KLAMATH COUNTY/CITY GEOTHERMAL SPACE HEATING

Submitted To
Klamath County

by

Oregon Institute of Technology
Geo-Heat Utilization Center

Amount Requested $7,012 Duration 8 weeks Starting Date June 21, 1976

ENDORSEMENTS

	Project Manager	Approving Administrative Official OIT	Approving Administrative Officials Klamath County
Name	Paul J. Lienau	[illegible]	Raymond P. Thorne
Title	Director, Geo-Heat Utilization Center	President	Chairman of the Board
			Bryan Williams County Commissioner
Date	5-12-76	5/21/76	Lloyd Gift County Commissioner
		By and For the Oregon State Board of Higher Education	5/27/76 Date
			By Board of County Commissioners

Conceptual Design/Feasibility Study
for
Klamath County/City Geothermal Space Heating

ABSTRACT

A geothermal space heating project has been initiated by the Klamath County Commissioners to provide geothermal energy for space heating of Klamath County/City buildings.

This study, to be performed by Geo-Heat Utilization Center personnel, is to establish methods by which the Klamath County Courthouse building, County Jail, Memorial building, Elks building, Library, City Jail, and City Hall could be economically converted to utilize geothermal energy for space heating in lieu of or in conjunction with presently installed more conventional heating systems. The study will result in a conceptual design and feasibility report and a formal proposal requesting funds for the final design and construction of the project.

Narrative

A. Study Objectives

1. Perform a conceptual design/feasibility study to convert Klamath County Courthouse building, County Jail, Memorial building, Elks building, Library, City Jail, and City Hall to geothermal space heating utilizing the well located at the Klamath County Museum.

2. Write a proposal to be submitted to appropriate agencies for the final design and construction of the project.

B. Background Information

Geothermal waters of moderate temperature (less than 200°F), have been utilized for district space heating in isolated cases throughout the world. Perhaps the most significant utilization is the capital city of Rekyjavik, Iceland, where 88,000 people have virtually all of their space heat provided from hot geothermal wells.

Nine downtown Klamath Falls churches are considering using geothermal energy to provide their space heating requirements. After determining estimated costs of installing a geothermal system, it appears that capitalization, operation and maintenance costs amortized over a 25 year period are about half of the 1975 heating season fuel costs.

Geothermal energy also provides insurance against rising prices of fossil fuels (coal, oil and natural gas).

C. Study Plan. To meet the objectives of this project, the following tasks will be accomplished in sequential order.

1. The museum well's potential and characteristics will be determined by performing a temperature gradient measurement and pump test to determine maximum output.

The pump test will help determine the potential of the museum well and the effect on nearby wells which will be monitored before and during pump test.

2. Heating load requirements for each building will be computed from plans, if available. If plans are not available, measurements necessary to compute heating load will be made.

3. Recommendations for retrofitting requirements and estimated cost to convert each building from conventional heating methods to geothermal will be made.

4. Recommendations on transmission/distribution pipeline in terms of route, type, size, pumps, network controls, and estimated costs will be made.

5. Options for disposal of geothermal fluids will be studied and a recommendation made according to method and cost.

6. Estimated cost effectiveness in terms of capitalization, operation, and maintenance of the geothermal heating system will be compared to conventional seasonal heating costs.

7. Based on the data gathered in this study a formal proposal will be written requesting funds for the final design and construction of a geothermal space heating system to be submitted by Klamath County to appropriate agencies.

D. Organization and Management Plan

The study will be performed by personnel from the Geo-Heat Utilization Center at Oregon Institute of Technology. The project director will be Paul J. Lienau, who will direct, coordinate and control this project.

The proposed work plan according to the study plan to accomplish the objectives of this study is as follows:

	Week (begin June 21, 1976)							
Task from Study Plan	1	2	3	4	5	6	7	8
1	X							
2	X	X	X	X				
3			X	X	X			
4				X	X	X		
5					X			
6					X	X		
7					X	X	X	
Final Report								X

E. Budget

1. Salaries

7 man weeks @ $550 per week (Culver, Lienau and Lund)	$3,850	
Other payroll expenses (OPE) @ 15%	578	
Total Salaries		$4,428

2. Services and Supplies

Drafting, reproduction and film	$ 600	
Phone	100	
Local travel	100	
Total Services and Supplies		$ 800
Required Overhead for OIT @ 15%		784
Pump Test		1,000
Total Budget		$7,012

CONCEPTUAL DESIGN/FEASIBILITY STUDY
FOR
KLAMATH COUNTY/CITY GEOTHERMAL SPACE HEATING

ADDENDUM TO BUDGET

The following endorsements approves additional funding to Oregon Institute of Technology for the pump test performed on the Klamth County Museum Well.

ITEM	COST
Cost of County Museum Pump Test	$2,085.55
Original amount budgeted for test	1,000.00
Additional Funding Approved	$1,085.55

ENDORSEMENTS

Project Manager

Name Paul J. Kiernan

Title Director, Geo-Heat Utilization Center

Date 9-14-76

Approving Administrative Officials
Klamath County

Chairman of the Board

Bryan Williams
County Commissioner

Floyd Gift
County Commissioner

September 14, 1976
Date

By Board of County Commissioners

APPENDIX B

PRODUCT DIRECTORY AND ESTIMATING PRICES

PRODUCT DIRECTORY

Pipeline Suppliers

1. Uninsulated:

   a. Transite
      Mr. Howard D. Harvey
      Johns-Manville
      215 Market Street
      San Francisco, CA 94105

   b. CPVC
      B.F. Goodrich Chem. Co.
      6100 Oak Tree Boulevard
      Cleveland, OH 44131

2. Factory Insulated Piping Systems:

   a. Rovanco Corporation - FRP Insul-8
      Mr. Jim Curry
      4315 McCallister Place
      Washougal, WA 98671
      Phone (206) 835-5585

   b. Temp-Tite
      (Address as above, 1a.)

3. Site Insulated Piping Systems:

   a. Protexulate
      Div. Pluess Staufer (North American) Inc.
      One World Trade Center
      Suite 2173
      New York, NY 10048
      Phone (212) 466-0550

   b. American Gilsonite Company
      1150 Kennecott Building
      Salt Lake City, UT 84133
      Phone (801) 328-0311

   c. Foamglass
      The E. J. Bartells Company
      524 North Tillamook Street
      Portland, OR
      Phone 282-3291

Heat Exchangers

1. Bert Farnes Company
   Mr. Larry Paulus
   10805 S.E. Cascade Boulevard
   Portland, OR 97223
   Phone (503) 639-1557

2. Bell and Gossett ITT
   8200 North Austin Avenue
   Morton Grove, IL 60053

Controls

1. Johnson Control
   Mr. Daniel Green
   Portland, OR

2. Branom Instruments
   Mr. Dennis Rainey
   Medford, OR 97501

Pumps

1. Interstate Pump Company, Inc.
   Mr. Lee Campbell
   7209 South Sixth Street
   Klamath Falls, OR 97601

Drilling Costs

A. Drilling:

	12-inch	14-inch
1. Soft to 500 ft.	$ 9.60/ft.	$11.20/ft.
2. Rock to 500 ft.	24.00/ft.	28.00/ft.

3. 500 ft. cost increases $1/ft. for every 100 ft.
4. 10 percent increase in 30 days

B. Casing:

12-in. - $9.60/ft., installed
10-in. - $9.13/ft.
10 percent increase in 30 days

C. Downhole Heat Exchanger (DHE):

2-in. - $1.56/ft., Mud Leg - $25

When a DHE is used, the pipe length is approximately twice the depth of a bore hole. A 12-inch bore hole receives a 10-inch casing preforated at producing aquifer and below static water level.

D. Well Completion:

1. Cement/Bentonite - $7.75/sack installed
2. High carbon shoe on 12 in. - $150
3. Mud clean-out - first hour on driller, $85/hr thereafter. Clean-out normally requires three to four hours.

The above costs were quoted july 22, 1976, and are subject to change without notice.

Johns-Manville
Sales Corporation

215 Market Street
San Francisco, Calif. 94105
(415) 362-4353

January 4, 1977

Mr. Paul J. Lienau, Physicist
Oregon Institute of Technology
Klamath Falls, Oregon 97601

Dear Mr. Lienau:

The following are estimating prices for the proposed county heating district in Klamath Falls:

4100 ft.	8" Temp-Tite	$18/ft.
3550 ft.	8" Class 150 Transite	$ 4/ft.
1050 ft.	3" Temp-Tite	$ 9/ft.
1050 ft.	4" Class 150 Transite	$ 2/ft.
8000 ft.	14" Temp-Tite	$40/ft.
or		
8000 ft.	16" Temp-Tite	$50/ft.

The above estimating prices include the necessary couplings and rings for assembly but do not include any fittings. Freight to Klamath Falls has been included in these prices.

Should you require any further information, please do not hesitate to let me know.

Yours very truly,

Howard D. Harvey

Howard D. Harvey

14" Class 150 Transite $9/ft
16" Class 150 Transite $11/ft

technical data

Johns-Manville JM
Transite® Ring-Tite® Pressure Pipe
Class 100 - 150 - 200 psi
TRX-1

Manufacture & Properties

Johns-Manville TRANSITE Pipe is an asbestos-cement product. It is composed of an intimate mixture of Portland cement, silica and asbestos fiber. The material is completely free from organic or metallic substances. The pipe is formed under pressure on a steel mandrel creating a dense wall with a smooth interior surface. Final curing of the product is done in an autoclave employing high pressure steam for dimensional and chemical stability.

TRANSITE pipe is an asbestos-fiber-reinforced product. The asbestos fibers have a tensile strength as high as 400,000 psi and the fibers are oriented in the material in such a way as to utilize their high tensile properties for maximum reinforcement and stress resistance. The high strength of TRANSITE pipe may be demonstrated by examining the hydrostatic and crush strengths of each size and strength of pipe. (See below.) Continuous plant testing assures the maintenance of these high values.

Flow Characteristics

TRANSITE pipe comes in 10' and 13' lengths. The long length, its smooth interior and factory-made close-tolerance joint make possible a coefficient of C=140. This high carrying capacity can result in the use of smaller diameter pipes and lower pumping costs.

Hydrostatic Strength

Each standard, random and short length of Transite water pipe is designed to have sufficient strength to withstand an internal hydrostatic pressure listed in the table below.

ROUTINE HYDROSTATIC PRESSURE, PSI (5 second dwell)	CLASS	100	150	200
	TEST PRESSURE	350	525	700

SAMPLING* HYDROSTATIC TEST PRESSURE, PSI (5 second dwell)	CLASS	100	150	200
	TEST PRESSURE	400	600	800

* One standard length in every 300 is tested to pressures shown and then retested to routine pressure.

Flexural Strength

Each standard length of Transite water pipe in sizes 4, 6 and 8 inches has sufficient strength to withstand, without failure, total loads listed in table below, when applied at the third points of a clear span at a minimum rate at least 500 lbs. per second maintained for five seconds. The supports shall be 9' apart except that, at the manufacturer's option, lengths greater than 12.5' may be tested on supports 12' apart.

NOMINAL PIPE SIZE, INCHES	TOTAL APPLIED LOAD, POUNDS		
	CLASS	9' SPAN	12' SPAN
4	100	1200	–
	150	1470	–
	200	1870	–
6	100	2800	2100
	150	3700	2800
	200	4900	3700
8	100	5330	4000
	150	7600	5700
	200	10130	7600

Design Approach

The strength of asbestos-cement water pipe must be sufficient to withstand the combined forces of internal hydrostatic pressure and external loads. Furthermore, the conditions under which the pipe is installed have a direct relationship to its ability to resist these forces. Therefore, satisfactory pipe performance in field service requires that the bedding conditions, as well as the internal and external forces acting on the pipe, be taken into consideration in selecting a class of pipe for any given installation. Sound engineering practice requires that adequate safety factors be applied to strength requirements to insure performance under less than ideal conditions.

Research tests and the application of statistical analysis have shown that asbestos-cement pipe strength may be graphically illustrated by combined loading parabolic curves. The combined-loading theory developed by the late W. J. Schlick is presented in detail in the AWWA H2 Handbook "Standard Practice for the Selection of Asbestos Cement Water Pipe".) (AWWA C401)

This handbook has been prepared so that design engineers may quickly determine the correct class of asbestos-cement pipe to use under various combinations of internal pressure and external loading. Curves are included in this handbook to expedite the selection of the correct pipe class. Detailed analyses of the various structural factors affecting pipe design and selection are treated under separate headings.

Crushing Strength

Transite water pipe has the crushing strength indicated in the table to the right when tested in accordance with the ASTM 3-Edge Bearing Method.

NOMINAL PIPE SIZE, INCHES	CRUSHING STRENGTH PER LINEAR FT, LB		
	CLASS 100	CLASS 150	CLASS 200
4	4,100	5,400	8,700
6	4,000	5,400	9,000
8	4,000	5,500	9,300
10	4,400	7,000	11,000
12	5,200	7,600	11,800
14	5,200	8,600	13,500
16	5,800	9,200	15,400

Physical Characteristics

STANDARD LENGTHS (NOMINAL)

PIPE SIZES	STANDARD LENGTHS
4"	10'
6"	10' & 13'
8" thru 16"	13'

Weights

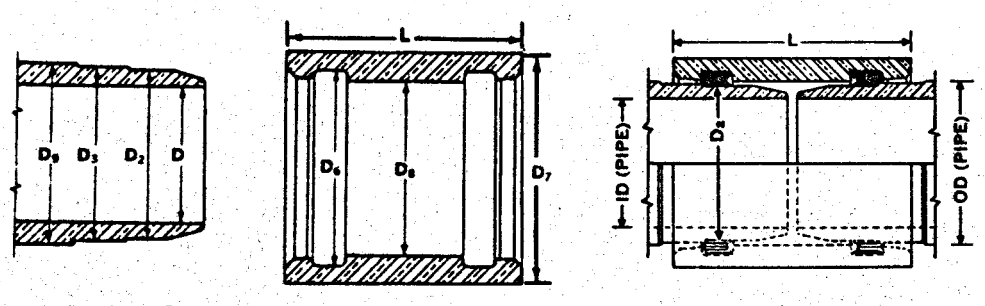
PIPE SIZE INCHES	CLASS 100		CLASS 150		CLASS 200	
	PIPE WGT LBS PER FT*	CPLG WGT EACH	PIPE WGT LBS PER FT*	CPLG WGT EACH	PIPE WGT LBS PER FT*	CPLG WGT EACH
4	6.1	6.6	7.2	7.4	8.8	7.4
6	11.1	10.6	12.3	11.3	14.5	12.4
8	16.5	13.5	18.7	17.5	22.2	18.9
10	22.7	17.1	29.9	26.8	34.5	28.9
12	32.1	26.4	41.0	41.5	48.2	46.8
14	39.2	37.1	55.0	64.2	64.7	72.7
16	50.0	45.6	68.3	81.0	83.7	91.8

* Includes pipe, coupling and rings.

PIPE & COUPLING DIMENSIONS (INCHES)

SIZE Pipe inches	D	D_2	D_3	D_6	D_7*	D_8	D_9* min.	D_9* max.	L
CLASS 100									
4	4.00	4.64	4.80	5.38	6.38	4.76	4.79	5.14	7.00
6	6.00	6.91	7.07	7.65	8.85	7.03	7.05	7.40	7.00
8	8.00	9.11	9.27	9.85	11.05	9.23	9.22	9.57	7.00
10	10.00	11.24	11.40	11.98	13.25	11.36	11.42	11.77	7.00
12	12.00	13.44	13.60	14.18	15.70	13.56	13.69	14.04	8.00
14	13.59	15.07	15.23	15.95	17.59	15.20	15.40	15.80	9.00
16	15.50	17.15	17.31	18.03	19.86	17.28	17.54	17.94	9.00
CLASS 150									
4	4.00	4.81	4.97	5.55	6.67	4.93	4.97	5.27	7.00
6	5.85	6.91	7.07	7.65	8.96	7.03	7.07	7.37	7.00
8	7.85	9.11	9.27	9.85	11.52	9.23	9.27	9.57	7.00
10	10.00	11.66	11.82	12.40	14.51	11.78	11.82	12.12	7.00
12	12.00	13.92	14.08	14.66	17.15	14.04	14.08	14.38	8.00
14	14.00	16.22	16.38	17.10	20.00	16.35	16.38	16.73	9.00
16	16.00	18.46	18.62	19.34	22.64	18.59	18.62	18.97	9.00
CLASS 200									
4	4.00	4.81	4.97	5.55	6.67	4.93	5.22	5.57	7.00
6	5.70	6.91	7.07	7.65	9.10	7.03	7.26	7.56	7.00
8	7.60	9.11	9.27	9.85	11.66	9.23	9.39	9.74	7.00
10	9.63	11.66	11.82	12.40	14.69	11.78	11.77	12.12	7.00
12	11.56	13.92	14.08	14.66	17.48	14.04	14.03	14.38	8.00
14	13.59	16.22	16.38	17.10	20.42	16.35	16.48	16.88	9.00
16	15.50	18.46	18.62	19.34	23.11	18.59	18.79	19.19	9.00

* Subject to manufacturing tolerances.

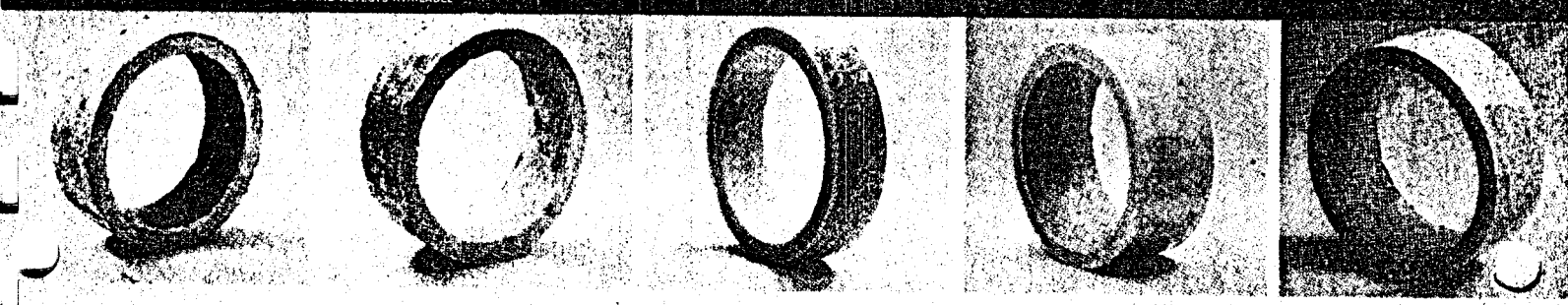


Corrosion Resistance

Pictured below are pipe samples taken from in-service lines—many years old—where aggressive waters and soils have been the best indices of Transite pipe's resistance to corrosion inside, outside, and all-the-way-through. Transite pipe is immune to rust, electrolysis, galvanic and electrochemical types of corrosion. Numerous installations for mine drainage, in cinder fills and for salt water disposal lines are further evidence of Transite pipe's high stability, maintained hydraulic efficiency and long, economical performance. They document why Transite pipe is considered the most corrosion-resistant water pipe in general use by the water works industry.

UNRETOUCHED PHOTOS OF PIPE SECTIONS REMOVED FROM OLD, IN-SERVICE TRANSITE WATER LINES.*

RESULTS OF EXAMINATION AND RETESTS AVAILABLE



DATE OF INSTALLATION . . Late 30's
PLACE . . Arkansas
NATURE OF SOIL . . Acid
DATE REMOVED . . 1962
LENGTH OF SERVICE . . . 27 years

DATE OF INSTALLATION . . 1938
PLACE . . Washington
NATURE OF WATER . . Aggressive
DATE REMOVED . . 1962
LENGTH OF SERVICE . . . 24 years

DATE OF INSTALLATION . . . 1937
PLACE . . North Carolina
DATE REMOVED . . 1962
LENGTH OF SERVICE . . . 25 years

DATE OF INSTALLATION 1942
PLACE . . Oregon
NATURE OF WATER . . . Aggressive
DATE REMOVED . . 1962
LENGTH OF SERVICE . . . . 20 years

DATE OF INSTALLATION 1950
PLACE . . Oregon
NATURE OF WATER . . Aggressive
DATE REMOVED . . 1962
LENGTH OF SERVICE . . . . 12 years

INSTALLATION

Installation Guide

The Johns-Manville Installation Guide (TR-62A) for Transite Pressure Pipe is available—at no cost—to Engineers, Superintendents, Contractors, Foremen and laying crews for guidance in following specifications. Order from your J-M representative or contact the nearest J-M Customer Service Center listed on the back page.

CONTENT OF GUIDE AS FOLLOWS:

Receiving and Handling .....
Excavating Trench .....
Supporting Pipe .....
Lowering Into Trench .....
Assembly of Pipe and Coupling .....
Use of Short Lengths .....
Cutting and Machining Pipe .....
Assembly at Fittings .....
Thrust Control at Fittings .....
Installation at Hydrants .....
Service Connections .....
Backfilling and Tamping .....
Pressure Tests—Leakage Tests .....
Repairs To Damaged Pipe .....
Pulling Pipe Through Casings .....
Bridge Crossings .....

Excavation and Bedding

As with other pipes, the trench for Transite pipe should be excavated with bell holes, or granular material placed under the pipe to provide uniform bearing along the full length of each section (Class C Bedding—WPCF M.O.P. 9). The narrowest practical trench at the top of the pipe which will allow preparation of the bedding and pipe assembly is recommended. This is usually considered to be the pipe diameter plus 18" to 24".

Handling

As with any pipe, Transite pipe should be handled in such a way as to avoid impact which might damage the pipe or the joining ends.
Two men can handle 4", 6" and 8" pipe manually. It's that light. They can handle 10" and 12" with ropes, and require mechanical equipment only with larger sizes. The light weight of Transite reduces cost of on-job hauling, storing, stringing out, lowering and assembly.

Joint Assembly

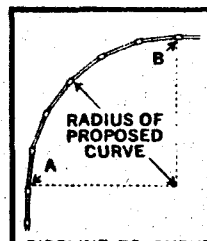
Transite Pressure Pipe is joined with Ring-Tite couplings and is factory-belled. A push or a pull is all that's needed to assemble. For smaller sizes only a bar and a block of wood is needed. For larger sizes efficient coupling pullers are used. Either way, assembly is fast, simple, sure. Stabbing or popping-on is not recommended as a method of assembly.

Thrust Control

Thrust control is required wherever the pipeline: changes direction, as at tees and bends; changes sizes, as at reducers; stops, as at dead-ends; or is expected to develop thrusts at valves. The type and extent of thrust control required depends on pipe size, pressures, type of soil and type of fitting. Thrust control is normally designed by the engineer. Location, type and size are his responsibility and should be included in the project plans and specifications.

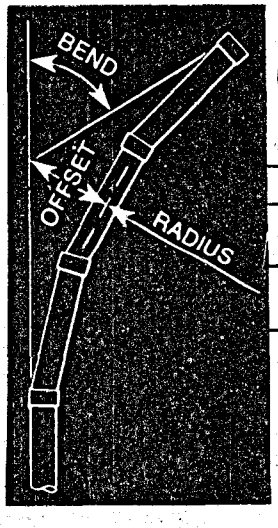
Minimum Radius of Curvature For Pipe on Curves

Transite pipe may be deflected at the joint within the limits (maximum) described and illustrated below. Because of deflection at the joint, curves in a line can often be made without fittings, reducing installation costs. Pipe to be deflected is assembled straight then offset as needed. Deflecting pipe sometimes requires a wider trench at the outside of the curve. If offset exceeds the maximum recommended for standard lengths the curve is too sharp. In this case, short lengths can be used to increase the number of joints and sharpen the curve.



MINIMUM RADIUS OF CURVE (FEET)		DEFLECTION PER COUPLING (Degrees)	OFFSET PER 13' LENGTH (Inches)
LENGTH OF PIPE (feet) 6½	13		
373.5	747	1°	2.7"
185.5	371	2°	5.4"
124.0	249	3°	8.1"
93.1	186	4°	10.9"
74.3	149	5°	13.6"

Pipe in sizes 4"-12" may be deflected up to 5°; pipes 14" and 16" up to 4°. These deflections apply to couplings belled on the job site. For factory-belled couplings, use one-half of the above deflections or offsets.



HOW TO ELIMINATE BENDS

To Eliminate X° Bend	Use Radius & Offsets Below		
Bend	Offset=2'	Offset=3'	Offset=4'
5°	R=2000'	R=3000'	R=4000'
11¼°	R=333'	R=750'	R=1000'
22½°	R=102'	R=153'	R=204'

Adaptability

Adaptability is an important advantage with Transite pipe, as fittings and valves are available with Ring-Tite joining design. The flexible connections made this way allow full pipe lengths to be used at fittings. Deflection can be taken at couplings which permits making changes in direction up to 5° whether horizontal or vertical. This flexibility helps by-pass trench obstructions. Short lengths are available to assist in accurately locating fittings. If exact location of fittings is necessary, Transite MOA (machined over-all) pieces are available to eliminate additional labor costs of machining in the field.

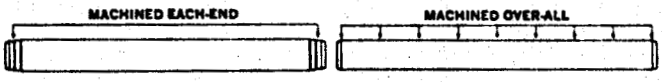
ACCESSORIES

Fittings — Adaptors — Connections

Transite Short Lengths (MEE & MOA)

As shown, short lengths may be machined-over-all (MOA) or machined-each-end (MEE). Following is a listing of the lengths and types of short lengths available:

For 4" and 6" (10 ft. lengths)	3'3" MOA	
	3'3" and	6'9" MEE
For 6" (13 ft. lengths)	3'3" MOA	
	3'3" and	6'6" MEE
For 8" thru 16"	3'3" and	6'6" MOA
	3'3" and	6'6" MEE

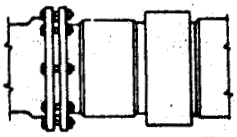


Fittings*

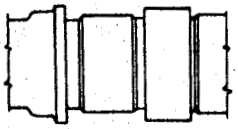
Cast iron fittings (including elbows, tees, crosses, reducers, valves and hydrants) are available with Ring-Tite bells in Classes 100, 150 and 200 for pipe sizes 4" through 16". Specify—"Cast Iron Fitting or Valve, with Ring-Tite Bells." Cast Iron Fittings conform to ASA A21.10 and AWWA C100 standard specifications. "Cast Iron Fittings with Standard Bell."

Adaptors

a. From Transite to C. I. Mech. Jt. or Poured Bell



AT MECHANICAL JOINT FITTING



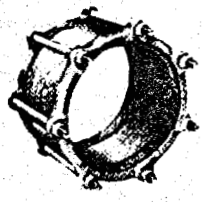
AT POURED BELL FITTING

b. Transite Class to Class

CLASS TO CLASS ADAPTOR

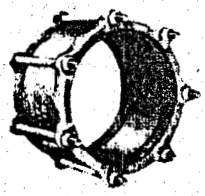
c. Transite (ME) to Flange*

d. Transite (PE) to Steel or PVC*



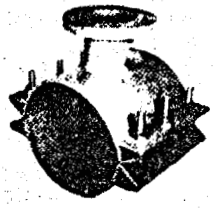
(PE) — Plain End

e. Transite (PE) to CI*



(ME) — Machined End

Tapping Sleeve*



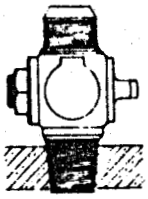
Fabricated with many types of outlets (M.J., Thd., Flange etc.)

*All accessories other than Transite brand available through your local Water Works Supply House.

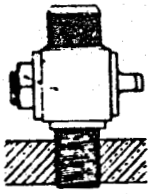
Service Connections

Transite Pipe can be tapped wet or dry, using standard water works equipment, for the insertion of corporation stops.* The largest size corporation stop which can be tapped directly into the pipe is given below. Larger outlet size can be secured by using service clamps. Corporation stops should be located at least one foot from pipe ends. If two insertions are made, one on each side of the main, they should be separated (measured along the pipe length) by at least one foot.

Pipe Size	Corporation Stop
4" thru 6" Classes 100 & 150 — 4" Class 200	¾"
6" Class 200	1"
8" thru 16" Classes 100, 150 & 200	1"

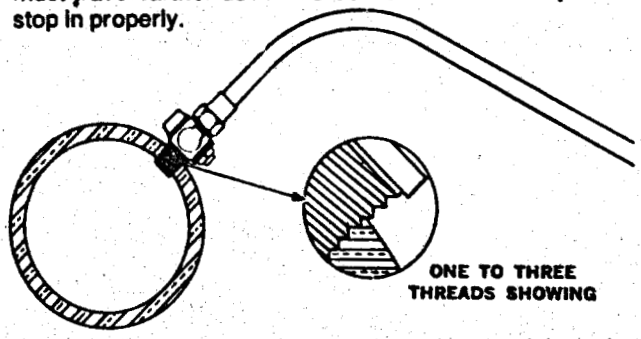


PIPE TAPPED FOR CORP. STOP THREAD



PIPE TAPPED FOR IRON PIPE THREAD

Transite pipe has a thick wall and will therefore engage more threads of the corporation stop—so the boring-bar must travel farther down in order to thread the corporation stop in properly.



A properly installed corporation stop—showing gooseneck in service pipe and detail of correct number of threads exposed after tightening.

Service Clamps*

Maximum Size of Outlet Recommended with Service Clamps (Inches)

Pipe Size	Single Strap	Double Strap
4"	1"	1"
6"	1½"	1½"
8"	2"	2"
10"	2"	2"
12"	2"	2"
14"	2"	2"
16"	2"	2"

Transite Bushed Couplings

AWWA THREAD

BRASS BUSHING

IRON PIPE THREAD

Specify either brass or galvanized iron bushing.

All bushings are threaded into coupling wall and securely bonded with epoxy cement.

OUTLET SIZES AVAILABLE	
4" Pipe	¾" — 1" — 1¼"
6" thru 16" Pipe	¾" — 1" — 1¼" — 1½"

Short Form Specification For Transite Asbestos Cement Pressure Pipe

SECTION 1. MATERIALS

1.1 **Pipe and Couplings,** in sizes indicated on the contract plans shall be Class 100, 150, or 200. All pipe and couplings shall be manufactured and tested in accordance with "AWWA Standard for Asbestos Cement Pressure Pipe for Water and Other Liquids" AWWA C400.

1.11 **Pipe** shall be properly machined on each end to facilitate joining the pipe sections and to provide automatic end separation of pipe in each coupling assembly.

1.12 Standard lengths shall be 10 feet in 4" (10' lg. also available in 6") and 13 feet in 6" through 16". Up to 10% of the total footage of any one size and class may be furnished in random lengths (7' min).

1.2 **Couplings** The inner surface of each coupling shall have gasket retaining grooves which, when the pipe is assembled, shall compress the gasket to form a water-tight seal.

1.3 **Rubber Rings** shall be of uniform solid cross-section and conform to ASTM D 1869 "Rubber Rings for Asbestos Cement Pipe".

SECTION 2. INSTALLATION

2.1 All pipe, couplings, fittings and rubber rings shall be installed in accordance with contract plans and specification and the "AWWA Standard for Installation of Asbestos Cement Water Pipe" AWWA C 603.

Warranty & Warranty Limitations

All products sold are subject to the following warranty: J-M warrants for a period of one year from date of delivery to the original retail purchaser that the Product is free from defects in materials and workmanship. J-M MAKES NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, IN FACT OR IN LAW, INCLUDING WITHOUT LIMITATION, THE WARRANTY OF MERCHANTABILITY OR THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. The limit of J-M's liability for failure of its Product to meet the foregoing warranty shall be, at J-M's sole option repair or replacement of the defective Product and shall exclude any damage caused by accident, misuse or abuse of the Product IN NO EVENT SHALL J-M BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

The physical (or chemical) properties of Johns-Manville TRANSITE Ring-Tite Pressure Pipe represent typical, average values obtained in accordance with accepted test methods and are subject to normal manufacturing variations. The indicated minimum values are as shown. This information is supplied as a technical service and is subject to change without notice. Check the Johns-Manville Customer Service Center or Local Representative to assure current information.

technical data

Johns-Manville JM

Temp-Tite® Pressure Pipe

for conveying chilled water and low temperature hot water (35-210°F) Sizes 3"-30"

CH-8

- **INSTALLS FASTER THAN MANY OTHER INSULATED PIPE SYSTEMS**
- **COSTS LESS INSTALLED**
- **OUTPERFORMS OTHER INSULATED PIPE SYSTEMS NOW AVAILABLE.**

This factory-insulated pipe is designed especially for central heating/cooling systems in multi-building projects.

Description

Factory insulated underground pipe—one unit that is completely non-metallic.

TRANSITE® CASING. Light and rugged autoclave cured asbestos-cement resists corrosion from aggressive soils and water. Withstands normal field handling associated with pipeline construction. Meets broadest range of earth loading conditions.

POLYURETHANE FOAM INSULATION is bonded between a lined casing and core, and capped at both ends with water and heat resistant end seals to ensure complete encasement ... to maintain high thermal efficiency.

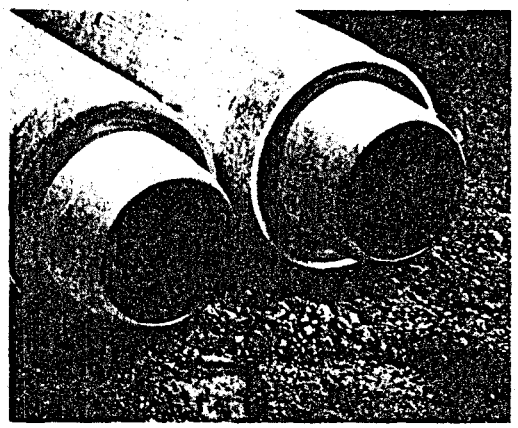
TRANSITE LINED PIPE CORE. Provides maximum flow rates (C=150) and eliminates internal corrosion.

RING-TITE® COUPLING with rubber rings provides proven, water-tight seal ... permits quick easy assembly, even in a wet trench ... allows expansion and contraction in the joint ... eliminates need for loops, conventional expansion joints and other costly accessories.

Do not use for steam condensate.

K=.14 @ 50°F mean temperature
K=.16 @ 150°F mean temperature
Where "K" is expressed in BTU/inch/square feet/°F/Hr

Note: The foregoing values represent "average values." Since the apparent density of polyurethane foam may vary considerably within a confined area as compared to a "free rise" condition, the conductivity "K" may vary from .11 to .18 at either of the mean temperatures chosen. Furthermore, the ultimate age, the operating temperature, and cell structure of the foam may significantly affect the resultant conductivity "K" value.



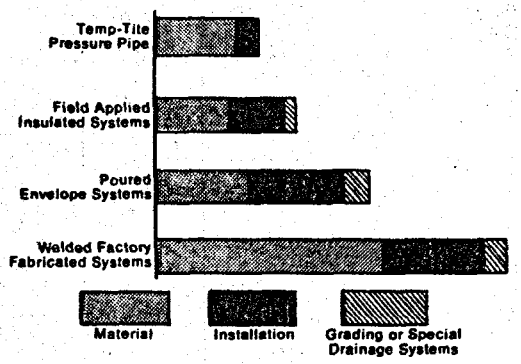
Approval or Acceptance

TEMP-TITE Pressure Pipe is manufactured and tested in accordance with Johns-Manville Material Specification. Performance requirements for individual component parts, as indicated in the J-M Specifications, meet or exceed those covered in the following specifications:

AWWA-C400 TYPE II ASTM-C296
ASTM-C428 TYPE II ANSI-A165.3, ANSI-J8.7
ASTM-D1869 Federal Spec. SS-P-351
ASTM-C541 (Upon application)

Cost Comparison Data

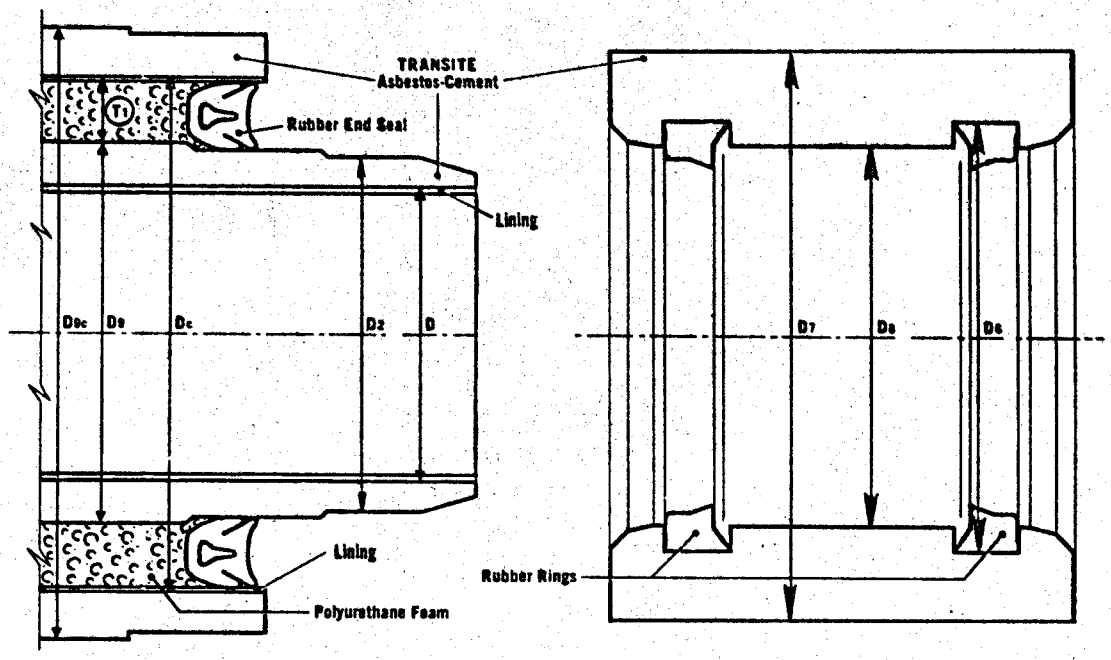
basis—8" diameter
100 ft. of pipe • no expansion loops or joints



This chart shows the relative installed cost of 8" Temp-Tite pressure pipe as compared to a range of other systems. The cost of required expansion joints and/or loops is not included. The above comparison provides for all materials, labor and normal excavation and back fill costs. Special grading or draining systems normally required under wet trench conditions is estimated as shown.

Product Detail

TEMP-TITE Pressure Pipe conforms to the dimensions shown below. Each pipe is properly machined on each end so as to facilitate joining the pipe sections without damage and to automatically provide an end separation of pipes in each coupling assembly. The pipe ends are also compatible with the coupling so as to provide accurate confinement of the rubber sealing rings.

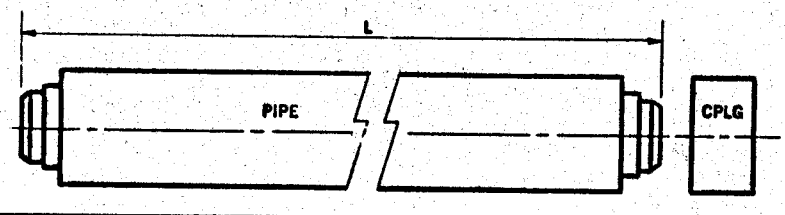


Pipe Size	D	D_2	D_9†	D_c	D_{9c}	D_6	D_7	D_8	T_1
3	3.00	3.84	4.00	6.00	6.92	4.63	5.59	4.07	1.00
4	3.95	4.81	4.97	8.00	9.02	5.60	6.58	5.04	1.52
6	5.85	6.91	7.07	9.00	9.88	7.70	8.96	7.14	0.97
8	7.85	9.11	9.27	12.00	13.22	9.90	11.52	9.34	1.37
10	10.00	11.66	11.82	14.00	15.07	12.45	14.51	11.89	1.09
12	12.00	13.92	14.08	16.00	17.48	14.71	17.15	14.15	0.96
14	14.00	16.22	16.38	18.40	20.15	17.15	20.00	16.46	1.01
16	16.00	18.46	18.62	20.80	22.80	19.39	22.64	18.70	1.09
18	18.00	20.94	21.10	24.00	25.78	21.87	25.12	21.18	1.45
20	20.00	23.28	23.44	25.45**	27.80**	24.21	27.65	23.52	1.01
24	24.00	27.96	28.12	30.00	32.85	28.89	32.92	28.20	.94
30	30.00	35.00	35.16	38.00	41.40	35.93	41.18	35.24	1.42

†Subject to manufacturing tolerances

**Dimension Dc is 26.85 from Long Beach Plant
" D9c is 28.35 " " " "

sizes, lengths (nominal) and weights



PIPE SIZES	STANDARD LENGTHS (L)	SHORT LENGTHS (L)	
		MOA	MEE
3" & 4"	10'	3'-3"	6'-9"
6"	13'	3'-3"	6'-6"
8" thru 30"	13'	6'-6"	6'-6"

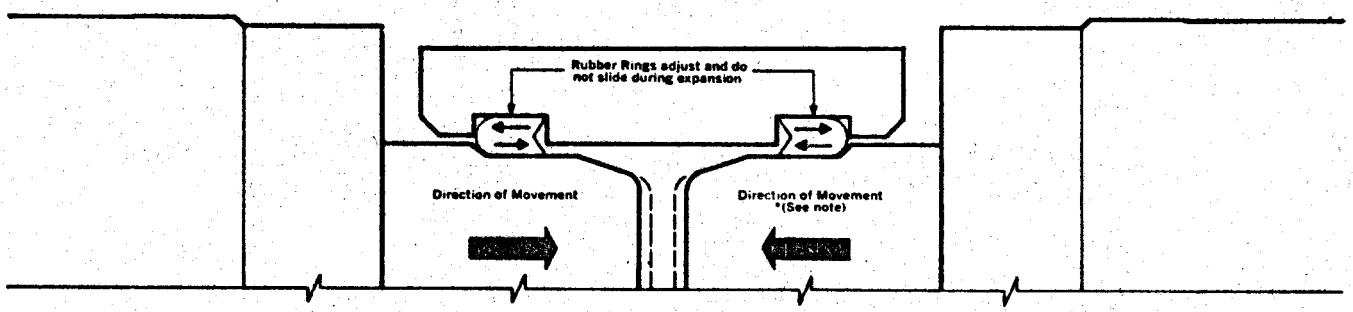
APPROXIMATE WEIGHTS OF PIPE INCLUDING COUPLING

Sizes	Lbs./Ft.
3	13.2
4	19.3
6	23.1
8	39.9
10	50.7
12	72.8
14	96.4
16	123.8
18	147.5
20	190.0
24	271.0
30	417.0

minimum crushing strength* (casing only)		Recommended Design Temperatures and Pressures		
Pipe Size	Lbs. Per Linear Ft.	Maximum Water Temperatures		Operating Pressure
		Continuous	Surge*	
3" thru 10"	1500	210°F	230°F	130 psi
12" thru 30"	2400	200°F	220°F	150 psi
*ASTM 3-edge bearing method.		*The temporary surge allowance shown provides for unforeseen operating malfunctions and is not recommended as an intermittent operating level. However, in no instance is Temp-Tite pipe recommended to be used in excess of the foregoing conditions, regardless of pressure.		

thermal expansion

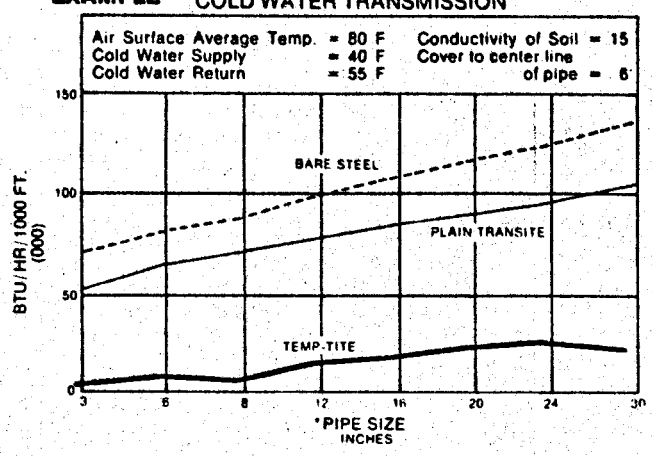
Coefficient of Expansion for Wet Transite = 4.5×10^{-6} in/in/°F



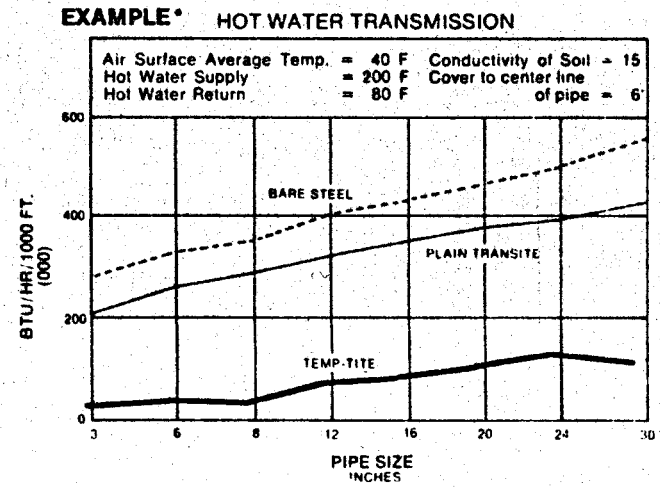
*Expansion takes place in each length of pipe and is not cumulative. Spacing between pipe ends varies, with a minimum of .25". This minimum provides a space safety factor of .11" for a 200°F temperature change.

Comparative Thermal Data

EXAMPLE* COLD WATER TRANSMISSION



EXAMPLE* HOT WATER TRANSMISSION



ECONOMICS CHILLED WATER

Example:

5,000' of 8" Bare Steel — Heat Gain = 405,000
5,000' of 8" Temp-Tite — Heat Gain = 40,000
Net Diff. = 355,000 BTU/HR.

In 1 year (8760 HRS.) Heat Gain = 3,109,800,000 BTU, or 259,150 Tons/Yr. Assuming 10¢/TON/Hr, the additional cost per year for not insulating will be approximately $25,915. If cost of money is 7%, the present worth of this Heat Gain is:

$106,252 in 5 yr. period
$182,027 in 10 yr. period
$274,440 in 20 yr. period

This does not consider the further adverse effects of inflation, nor changes in energy costs.

ECONOMICS HOT WATER

Example:

5,000' of 8" Bare Steel — Heat Loss = 1,790,000
5,000' of 8" Temp-Tite — Heat Loss = 230,000
Net Diff. = 1,560,000 BTU/HR.

In 8 months (5840 HRS.) Heat Loss = 9,110,400,000 BTU. Assuming a million BTU's to be worth $3.00, the additional cost per year for not insulating will be approximately $27,162. However, if cost of money is 7%, the present worth of this Heat Loss cost is approximately:

$111,364 in 5 yr. period
$190,786 in 10 yr. period
$287,646 in 20 yr. period

This does not consider the further adverse effects of inflation, nor changes in energy costs.

***Johns-Manville can provide you with a detailed heat loss/gain computer analysis which will include a financial analysis if so desired. Your Johns-Manville representative will be pleased to advise you of the details.**

Pressure Pipe Friction Loss of Head Chart

COEFFICIENT OF FLOW C-150 Derived from the Williams and Hazen Formula.
TEMP-TITE PIPE

GPM	3" Vel fps	3" Head Loss ft/1000	4" Vel fps	4" Head Loss ft/1000	6" Vel fps	6" Head Loss ft/1000	8" Vel fps	8" Head Loss ft/1000	10" Vel fps	10" Head Loss ft/1000	12" Vel fps	12" Head Loss ft/1000	14" Vel fps	14" Head Loss ft/1000	16" Vel fps	16" Head Loss ft/1000
25	1.13	1.78														
50	2.27	6.40	1.28	1.58												
75	3.40	13.60	1.91	3.55												
100	4.54	23.00	2.55	5.70	1.19	0.89										
125	5.67	35.00	3.19	7.31	1.49	1.35										
150	6.81	48.89	3.83	12.10	1.79	1.89										
175	7.94	64.18	4.47	16.02	2.09	2.53										
200	9.08	83.49	5.11	20.55	2.39	3.24										
225	10.21	104.00	5.74	25.51	2.69	4.01										
250			6.38	31.01	2.98	4.89										
275			7.02	37.00	3.28	5.82										
300			7.66	43.51	3.58	6.85										
325			8.30	50.50	3.88	7.95										
350			8.94	57.99	4.18	9.10										
375			9.57	66.00	4.48	10.36										
400			10.21	74.20	4.77	11.62										
425					5.07	13.05										
450					5.37	14.51	2.98	3.45								
475					5.67	16.03	3.15	3.83								
500					5.97	17.61	3.31	4.21								
525					6.27	19.30	3.48	4.60								
550					6.56	21.01	3.65	5.06								
575					6.86	22.95	3.81	5.46								
600					7.16	24.73	3.98	5.90	2.53	1.95						
625					7.46	26.60	4.14	6.36	2.63	2.10						
650					7.76	28.78	4.31	6.83	2.74	2.26						
675					8.06	30.60	4.47	7.31	2.84	2.42	2.01	1.05				
700							4.64	7.58	2.93	2.60	2.09	1.12				
725							4.81	7.85	3.05	2.77	2.16	1.20				
750							4.97	8.38	3.16	2.95	2.24	1.28				
775							5.14	8.92	3.26	3.15	2.31	1.36				
800							5.30	9.49	3.37	3.34	2.39	1.44				
825							5.47	10.03	3.47	3.52	2.46	1.52	1.82	0.73		
850							5.63	10.65	3.58	3.72	2.54	1.61	1.88	0.77		
875							5.80	11.22	3.68	3.94	2.61	1.70	1.94	0.82		
900							5.97	11.84	3.79	4.15	2.69	1.79	2.00	0.86	1.53	0.45
925							6.13	12.50	3.89	4.35	2.76	1.88	2.05	0.91	1.57	0.48
950							6.30	13.20	4.00	4.57	2.83	1.98	2.10	0.95	1.62	0.50
975							6.46	13.80	4.10	4.80	2.91	2.07	2.16	1.00	1.66	0.53
1000							6.63	14.51	4.21	5.01	2.98	2.17	2.21	1.03	1.70	0.55
1250							8.29	15.20	5.26	7.60	3.73	3.29	2.76	1.58	2.13	0.83
1500							9.94	23.00	6.32	10.63	4.48	4.60	3.32	2.22	2.55	1.17
1750									7.37	14.19	5.22	6.12	3.87	2.95	2.98	1.56
2000									8.42	18.15	5.97	7.85	4.42	3.79	3.40	2.00
2250									9.47	22.51	6.71	9.75	4.98	4.70	3.83	2.48
2500									10.53	27.49	7.46	11.86	5.53	5.71	4.25	3.01
2750											8.21	14.20	6.08	6.83	4.68	3.61
3000											8.95	16.60	6.64	8.00	5.10	4.21
3250											9.70	19.26	7.19	9.30	5.53	4.90
3500											10.44	22.10	7.74	10.62	5.95	5.60
3750													8.29	12.15	6.38	6.40
4000													8.85	13.70	6.80	7.20
4250													9.40	15.30	7.23	8.09
4500													9.95	17.00	7.65	8.81
4750													10.51	18.80	8.08	9.92
5000													11.06	20.60	8.50	10.90
5250															8.93	11.92
5500															9.35	13.02
5750															9.78	13.90
6000																

NOTE: Loss of head values derived from this chart are for coefficient of flow C-150. They may be converted to loss of head for other coefficients of flow by means of the following multiplying factors:

1.14 for C-140	2.12 for C-100
1.30 for C-130	2.57 for C- 90
1.51 for C-120	3.20 for C- 80
1.78 for C-110	5.46 for C- 60

NOTE: Diameters derived from this chart are for coefficient of flow C-150. These may be converted to diameters for other coefficients of flow by means of the following multiplying factors:

1.027 for C-140	1.167 for C-100
1.056 for C-130	1.214 for C- 90
1.088 for C-120	1.270 for C- 80
1.125 for C-110	1.417 for C- 60

COEFFICIENT OF FLOW C-150 Derived from the Williams and Hazen Formula.
TEMP-TITE PIPE

GPM	18"		20"		24"		30"		36"*	
	Vel fps	Head Loss ft/1000	Vel fps	Head Loss ft/1000	Vel fps	Head Loss ft/1000	Vel fps	Head Loss ft/1000	Vel fps	Head Loss ft/1000
1000	1.26	0.27	1.02	0.16						
1500	1.89	0.57	1.53	0.34	1.06	0.14				
2000	2.52	0.98	2.04	0.59	1.41	0.24				
2500	3.15	1.49	2.55	0.89	1.77	0.36	1.13	0.12		
3000	3.78	2.08	3.06	1.25	2.12	0.51	1.36	0.17		
3500	4.41	2.77	3.57	1.66	2.48	0.68	1.58	0.23	1.10	0.09
4000	5.04	3.55	4.08	2.12	2.83	0.87	1.81	0.29	1.26	0.12
4500	5.67	4.42	4.59	2.64	3.19	1.09	2.04	0.36	1.41	0.15
5000	6.30	5.37	5.10	3.21	3.54	1.32	2.27	0.44	1.57	0.18
5500	6.93	6.40	5.61	3.83	3.90	1.58	2.49	0.53	1.73	0.21
6000	7.56	7.52	6.13	4.50	4.25	1.85	2.72	0.62	1.89	0.25
6500	8.19	8.73	6.64	5.22	4.61	2.15	2.95	0.72	2.04	0.29
7000	8.83	10.01	7.15	5.99	4.96	2.46	3.17	0.83	2.20	0.34
7500	9.46	11.37	7.66	6.81	5.32	2.80	2.40	0.94	2.36	0.39
8000	10.09	12.81	8.17	7.67	5.67	3.16	3.63	1.06	2.52	0.43
8500			8.68	8.58	6.03	3.53	3.85	1.19	2.68	0.49
9000			9.19	9.54	6.38	3.93	4.08	1.32	2.83	0.54
9500			9.70	10.55	6.74	4.34	4.31	1.46	2.99	0.60
10000			10.21	11.60	7.09	4.77	4.54	1.61	3.15	0.66
10500					7.45	5.22	4.76	1.76	3.31	0.72
11000					7.80	5.69	4.99	1.92	3.46	0.79
11500					8.15	6.18	5.22	2.08	3.62	0.86
12000					8.51	6.69	5.44	2.26	3.78	0.93
12500					8.86	7.21	5.67	2.43	3.94	1.00
13000					9.22	7.76	5.90	2.62	4.09	1.07
13500					9.57	8.32	6.13	2.81	4.25	1.15
14000					9.93	8.90	6.35	3.00	4.41	1.23
14500							6.58	3.20	4.57	1.32
15000							6.81	3.41	4.73	1.40
15500							7.03	3.62	4.88	1.49
16000							7.26	3.84	5.04	1.58
16500							7.49	4.07	5.20	1.67
17000							7.71	4.30	5.36	1.77
17500							7.94	4.54	5.51	1.87
18000							8.17	4.78	5.67	1.97
18500							8.40	5.03	5.83	2.07
19000							8.62	5.28	5.99	2.17
19500							8.85	5.55	6.14	2.28
20000							9.08	5.81	6.30	2.39
20500							9.30	6.08	6.46	2.50
21000							9.53	6.36	6.62	2.62
21500							9.76	6.64	6.78	2.73
22000							9.99	6.93	6.93	2.85
22500									7.09	2.97
23000									7.25	3.10
23500									7.41	3.22
24000									7.56	3.35
24500									7.72	3.48
25000									7.88	3.61
25500									8.04	3.75
26000									8.19	3.89
26500									8.35	4.03
27000									8.51	4.17
27500									8.67	4.31
28000									8.83	4.46
28500									8.98	4.61
29000									9.14	4.76
29500									9.30	4.91
30000									9.46	5.07

* Pipe Available Uninsulated Only

Short Form Specification for TEMP-TITE Pressure Pipe

Section I MATERIALS

1.1 Pipe: All underground insulated pipe 3" and larger shall be Johns-Manville TEMP-TITE Pressure Pipe with RING-TITE joints. One TRANSITE RING-TITE coupling and two rubber rings shall be furnished with each standard and short length of pipe.

1.2 Fittings: All fittings shall be cast iron pressure fittings RING-TITE bells conforming to AWWA standard C-110 or welded steel fusion coated epoxy lined with Ring-Tite mechanical ends per AWWA-C201, C-209 modified, C-207, C-206 as manufactured by Pipeline Accessories Corp.

Section II INSTALLATION

2.1 All pipe, couplings, fittings, and rubber rings shall be installed in accordance with Johns-Manville's Installation Guides for TRANSITE RING-TITE Water Pipe (TR-62A) and Insulated Pipes (TR-616A) and as shown on the contract drawings.

JOHNS-MANVILLE PREINSULATED PIPES

	Sizes	Temperature Limits—°F	Operating Pressures—PSI	Service
COPPER CORE/ TEMP-TITE®	1"-2"	35-260	0-150	Water & Condensate
HEAT-TITE™	3"-8"	35-260	0-150	Water
TEMP-TITE®	3"-30"	35-210	0-150	Water
KOOL-KORE™	1½"-8"	35-73	0-160	Water
SUPER TEMP-TITE®	3"-12"	210-450	0-500	Water & Steam
CHEMTITE	2"-6"	35-210	0-100	Condensate

Warranty & Warranty Limitations

WARRANTY:
All Products sold are subject to the following warranty: J-M warrants for a period of one year from date of delivery to the original retail purchaser that the Product is free from defects in materials and workmanship. J-M MAKES NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, IN FACT OR IN LAW, INCLUDING WITHOUT LIMITATION, THE WARRANTY OF MERCHANTABILITY OR THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, OTHER THAN THE LIMITED WARRANTY SET FORTH ABOVE. Every claim under this warranty shall be deemed waived unless in writing and received by J-M within thirty (30) days of the date the defect to which each claim relates is discovered or should have been discovered.

LIMITATION OF LIABILITY:
It is expressly understood and agreed that the limit of J-M's liability shall be, at J-M's sole option, repair or resupply of a like quantity nondefective Product and that J-M shall have no such liability except where the damage results from breach of J-M's warranty. It is also agreed that J-M shall not be liable for any incidental or consequential damages, breach of warranty, strict liability, or any other theory, other than the limited liability set forth above.

The physical and chemical properties of Johns-Manville Pipe Products represent typical average values obtained in accordance with accepted test methods and are subject to normal manufacturing variations. They are supplied as a technical service and are subject to change without notice. Check the Johns-Manville Customer Service Center or local representative to assure current information.

For Information on other J-M Products and Systems call Product Information Center at (303) 770-1000 Ext. 2745

Johns-Manville

Greenwood Plaza • Denver, Colorado 80217

PIPE CUSTOMER SERVICE CENTERS
FLORIDA—P. O. BOX 185, GREEN COVE SPRINGS, 32043, (904) 284-3091
CALIFORNIA—P. O. BOX 9067, LONG BEACH, 90810, (213) 834-6471
CALIFORNIA—P. O. BOX 1587, STOCKTON, 95201, (209) 982-1500
ILLINOIS—P. O. BOX 46, WAUKEGAN, 60085, (312) 623-2900
NEW JERSEY—MAIN ST., MANVILLE, 08835, (201) 725-5000
TEXAS—DENISON, 75020, (214) 465-6390

CANADIAN JOHNS-MANVILLE CO., LIMITED • 565 LAKESHORE ROAD EAST, MISSISSAUGA, ONTARIO
MONTREAL • OTTAWA • TORONTO • WINNIPEG • FT. SASKATCHEWAN • VANCOUVER

JOHNS-MANVILLE INTERNATIONAL CORP., GREENWOOD PLAZA, DENVER, COLO. 80217 • CABLE: JOHNMANVIL
MIAMI • NEW YORK • SAN FRANCISCO

CH-8 8/75

Litho in U.S.A.

Series R56
Paraflow Plate Heat Exchanger

For pressures up to 125 psi

The Series R56 Paraflow, a lower pressure version of the R55 type unit, is a large capacity plate heat exchanger manufactured by APV for a wide range of heat transfer applications.

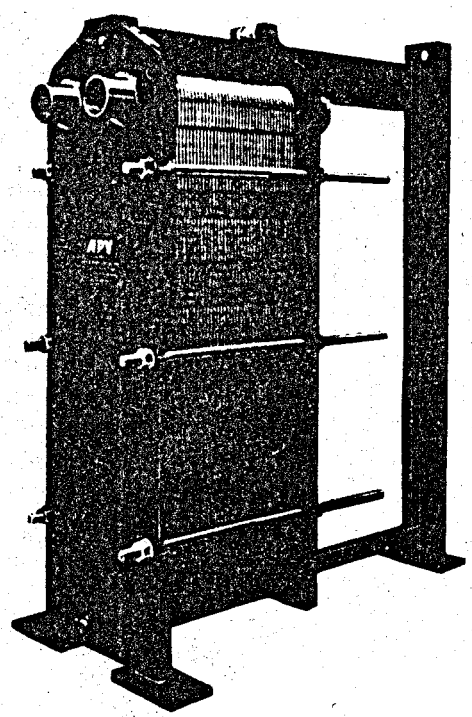
A strong but simple mild steel frame, finished in a chemical-resistant black paint, is available in five sizes. The unit is designed to provide up to 1960 sq. ft. of heat transfer surface when equipped with the maximum of 350 plates, and is engineered to permit the handling of up to 700 GPM of liquid with relatively low pressure losses.

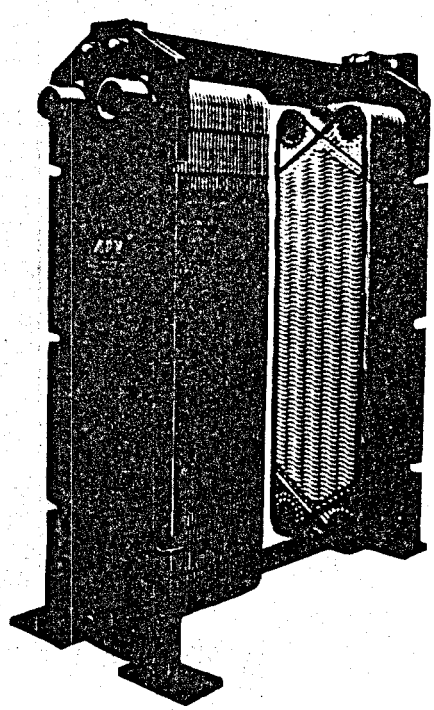
Series R56 plates, type II/150 low pressure, measure 61-1/4" x 16-3/8" and are manufactured as standard in 316 stainless steel. Gaskets are supplied in elastomers selected to withstand a wide range of liquids and temperatures.

The heat exchanger frame consists of a head and end support connected by a top carrying bar and a bottom guide rail. These form a rigid unit which supports the plates and follower. The follower may be unclamped and easily moved along the top bar to permit full access to all plate surfaces for cleaning or inspection, and each plate is individually replaceable. Six tie bars are used to clamp the follower and plates to the head.

Ports of 4" inside diameter have stainless steel liquid bushes and 4" sanitary 3A or stainless steel lap joint flanged connections.

Connector plates of stainless steel with either 4" or 2-1/2" ports are available to allow the Paraflow to be sectioned for multiple duties.





APV Paraflow, Series R56, closed and open.

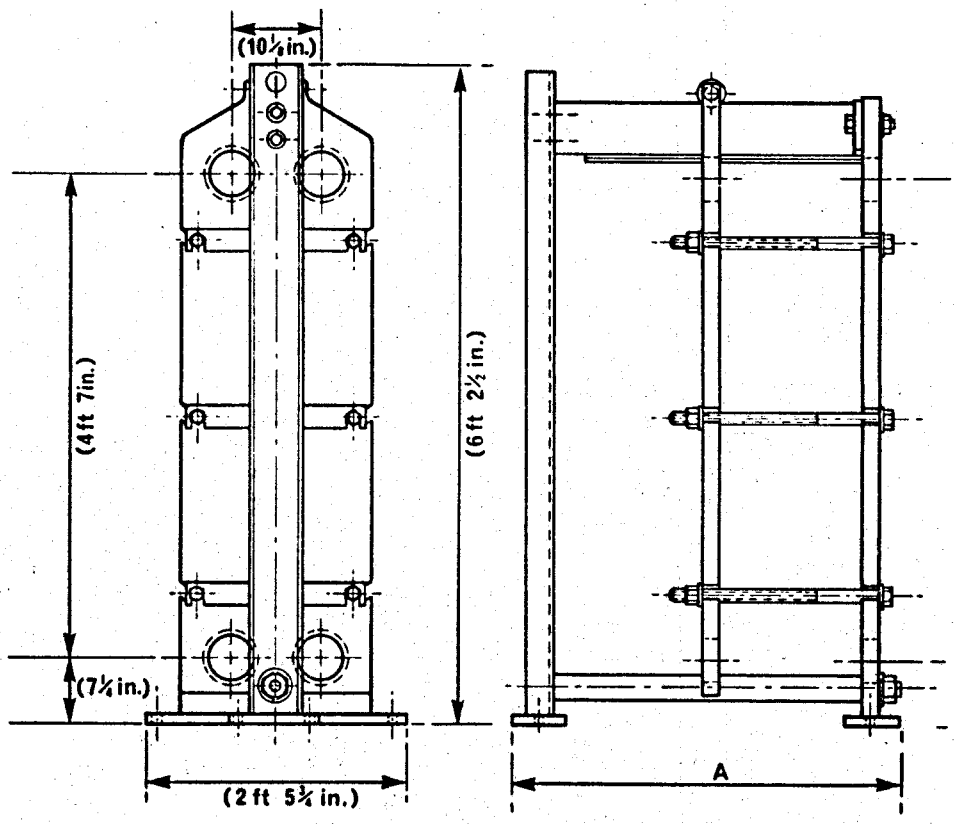
Accessories are quoted as additional items. These include commercially obtainable thermometers, pressure gauges, and steam fittings.

For a full description of the design and principle of the APV Paraflow Plate Heat Exchanger, request catalog A340.

SERIES R56	Heat transfer area per plate: 5.6 ft²

FRAME SIZE	TIE BAR SIZE	TYPE II/150 PLATE CAPACITY	LENGTH "A"
1	1	10 - 60	3' 8-1/2"
2	2	60 - 120	5' 1-1/4"
3	3	118 - 170	7' 3-1/2"
	4	168 - 215	
4	5	213 - 255	9' 0-3/4"
	6	253 - 290	
5	7	288 - 322	10' 5-1/2"
	8	320 - 350	

R56 plate weight: 8-3/4 lbs.
Frame weight: 2000 to 2400 lbs. according to size



A.P.V. COMPANY, INCORPORATED

Tonawanda Industrial Park, 395 Fillmore Avenue, Tonawanda, New York 14150 ■ Phone: (716) 692-3000

Representation in principal countries throughout the world

Series HXCB
Paraflow Plate Heat Exchanger

Type HXCB-4 (4 tie bars)
for pressures up to 60 psi

Type HXCB-6 (6 tie bars)
for pressures up to 100 psi

The Series HXCB Paraflow is a floor-mounted small capacity plate heat exchanger manufactured by APV for use as an integral part of equipment involving continuous heating or cooling of various liquids.

The unit will provide up to 87 sq.ft. of heat transfer surface when equipped with the maximum of 48 plates, and is engineered to handle up to 180 GPM of liquid with relatively low pressure losses.

Series HX plates measure 33" x 9" and are manufactured as standard in 20 swg stainless steel. Plates of other metals to meet special processing conditions also are available. Gaskets can be supplied in materials to suit the requirements of a wide range of liquids and temperatures.

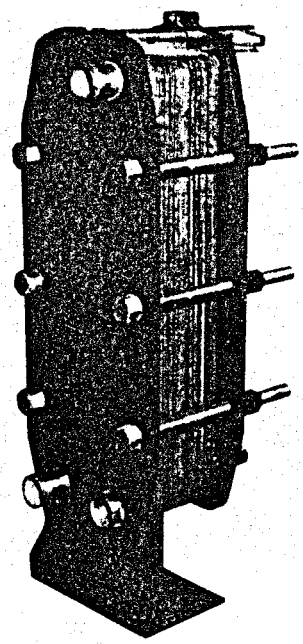
The heat exchanger frame consists of a head and follower of painted steel. The follower and plates are suspended between a top carrying rail and bottom guide bar, and all plate surfaces are easily accessible for cleaning or inspection.

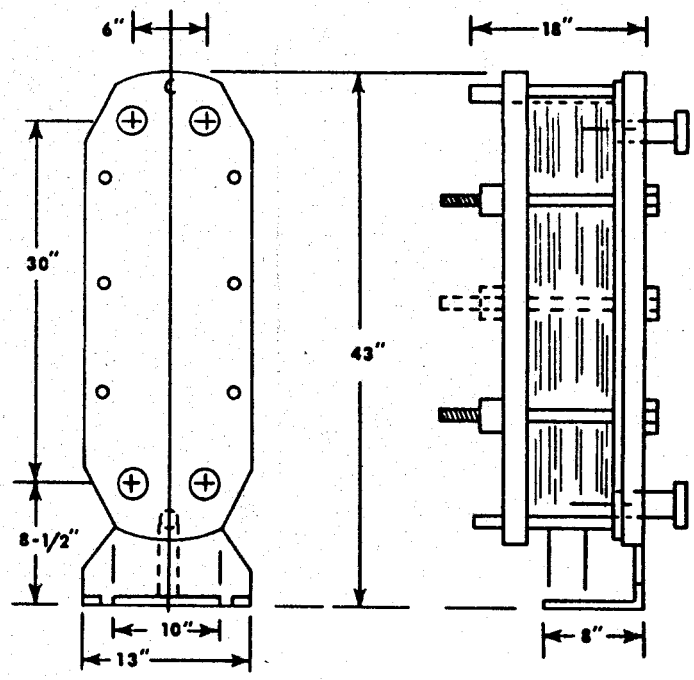
Ports of 2" inside diameter have stainless steel liquid bushes and 2" IPT, sanitary 3A, sanitary ISS, or stainless steel lap joint flanged connections.

Connector plates of stainless steel are available to allow the Paraflow to be sectioned for multiple duties.

Accessories are quoted as additional items. These include commercially obtainable thermometers, pressure gauges, and steam fittings.

For a full description of the design and principle of the APV Paraflow Plate Heat Exchanger, request catalog A340.





A.P.V. COMPANY, INCORPORATED

Tonawanda Industrial Park, 395 Fillmore Avenue, Tonawanda, New York 14150 ▪ Phone: (716) 692-3000

Representation in principal countries throughout the world

Series HMBL
Paraflow Plate Heat Exchanger

For pressures up to 100 psi

The Series HMBL Paraflow is a medium capacity plate heat exchanger manufactured by APV for a wide range of industrial liquid heating and cooling duties.

A strong but simple steel frame finished with a chemical resistant black paint is available in three sizes with capacities up to a maximum of 187 plates. The unit is designed to provide up to 686 sq.ft. of heat transfer surface when equipped with the maximum number of plates, and is engineered to permit the handling of up to 300 GPM of liquid with relatively low pressure losses.

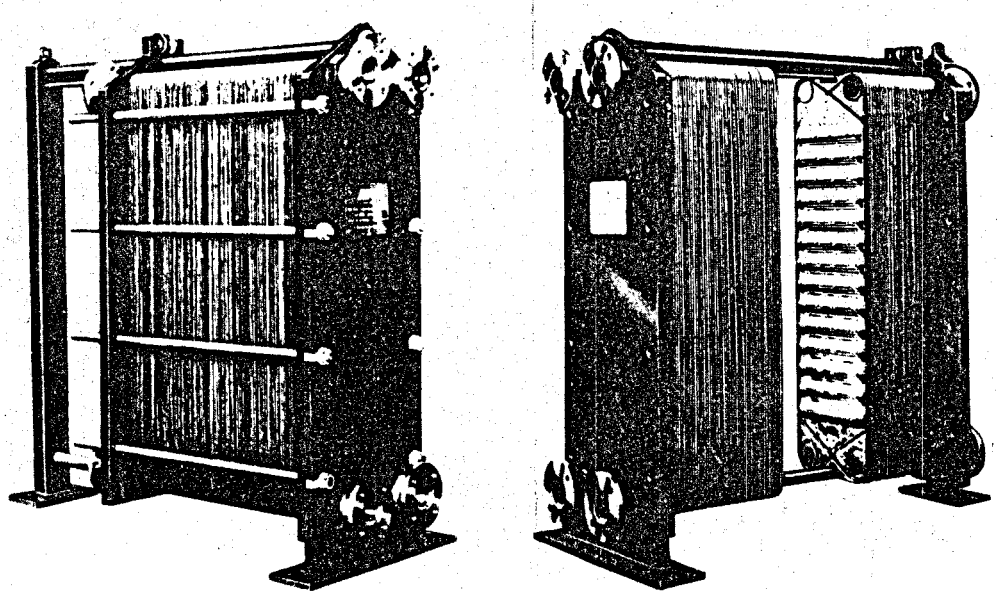
Series HMB plates measure 43-7/8" x 12-1/2" and are manufactured as standard in 20 swg stainless steel. Plates of other metals to meet special processing conditions also are available. Gaskets can be supplied in materials to suit the requirements of a wide range of liquids and temperatures.

The heat exchanger frame consists of a head and end support connected by a top carrying bar and a bottom guide bar to form a rigid unit which supports the plates and follower. The follower may be unclamped and easily moved along the top bar to permit full access to all plate surfaces for cleaning or inspection, and all plates may be individually removed from the unit.

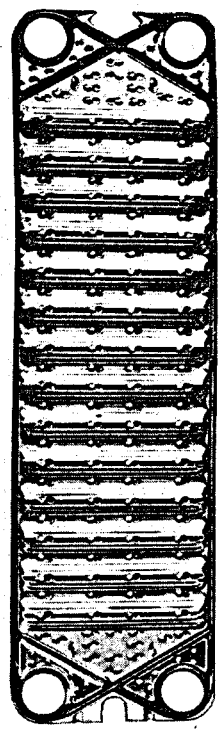
Ports of 2½" inside diameter have stainless steel liquid bushes with sanitary 3A or stainless steel lap joint flanged connections.

Connector plates of stainless steel are available to allow the Paraflow to be sectioned for multiple duties.

Accessories are quoted as additional items. These include commercially obtainable thermometers, pressure gauges, and steam fittings.



Series HMBL Paraflow, closed and open



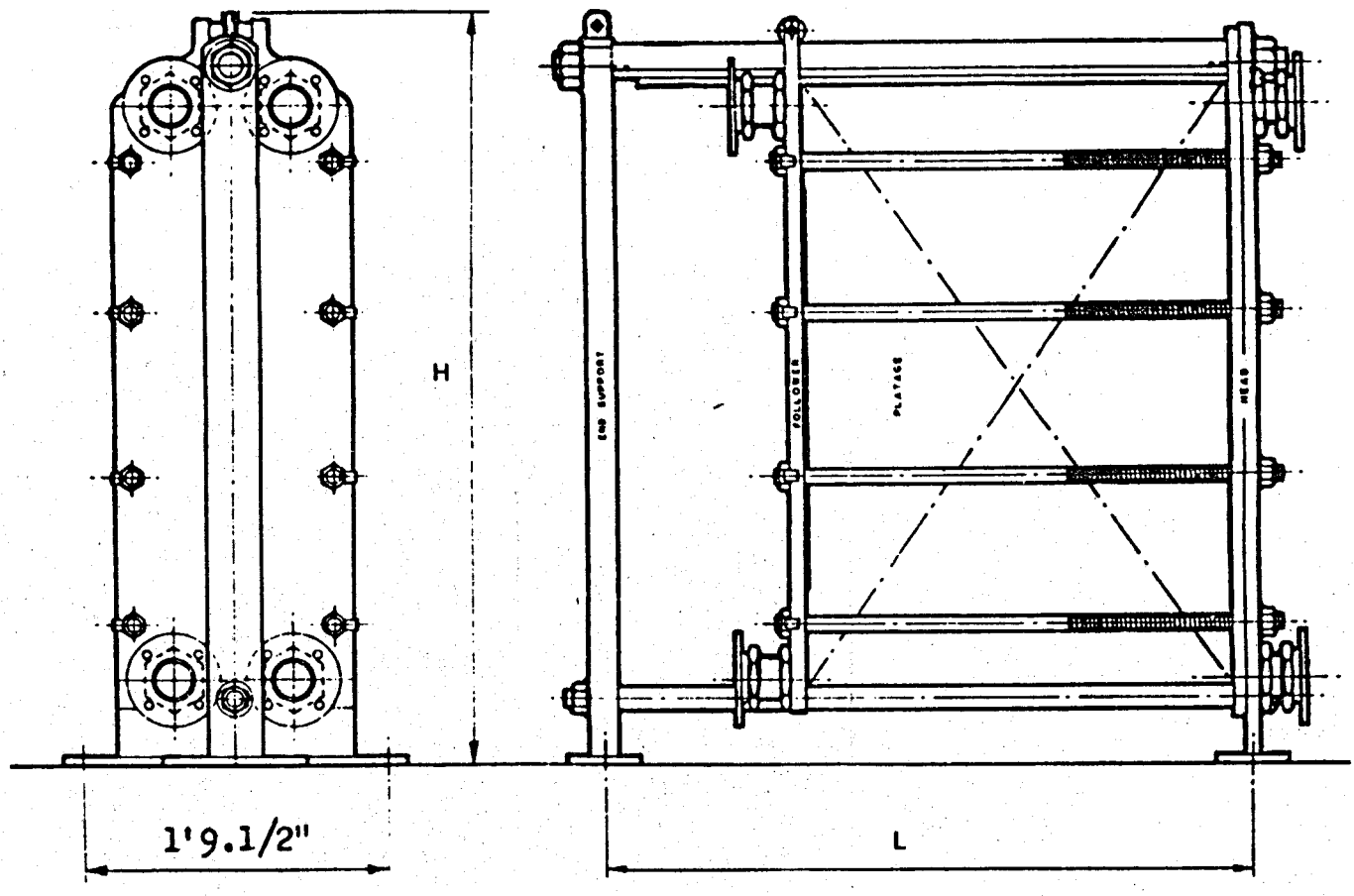
Series HMB Paraflow plate

For a full description of the design and principle of the APV Paraflow Plate Heat Exchanger, request catalog A340.

Heat transfer area per plate: 3.68 ft^2

SERIES	FRAME SIZE	TIE BAR SIZE	20 SWG PLATE CAPACITY	HEIGHTH "H"	LENGTH "L"	FRAME WT.
HMBL	1	1a	3 – 62	4'4¾"	3'9½"	850
		1b	62 – 96			
	2	2a	96 -- 124	4'4¾"	5'2¼"	1000
		2b	124 – 156			
	3	3	156 – 187	4'4¾"	5'11"	1150

HMB plate weight: 7¼ lbs.



A.P.V. COMPANY, INCORPORATED

Tonawanda Industrial Park, 395 Fillmore Avenue, Tonawanda, New York 14150 ■ Phone: (716) 692-3000

Representation in principal countries throughout the world

3C-1170

OREGON INSTITUTE OF TECH.

GEO*HEAT

KLAMATH FALLS, OREGON 97601

INTERSTATE PUMP CO., INC.

7209 South 6th St.

Klamath Falls, Oregon 97601

SUBJECT: WE QUOTE AS FOLLOWS : ESTIMATE ONLY:

FOLD HERE

DATE January 12, 1977

MESSAGE

1000 GPM @ 225' TDH

100 HP Motor Line Start 440V 3ø
100 HP Panel Line Start 440V 3ø
100HP Nelson Drive with Barber Control
Young raidator, Penn Heat Sensor, Amont control for safety
100 Ft. 8" x $2\frac{1}{2}$ x $1\frac{1}{2}$ Column, oil tube and shaft
17 AC 8 Discharge head
Bowl assembly for 184 degree F temp. 4" extra bowl laterial
Balanced impellers and keyed shaft.
10' 8" suction with stainless steel cone strainer

Installed on your base $ 24,896.00

Pulling of existing coils @ $25.00 per hr. plus $8.00 per hr for helper

NOTE: NO WIRING POLE OR METER BASE.. NO PLUMBING OF PIPE BEYOND PUMP.

SIGNED B Campbell

DATE

REPLY

SIGNED

FORM 1155, REGENT FORMS, PENNSAUKEN, N.J. 08109

•LETTER-LIMINATOR

RECIPIENT: RETAIN WHITE COPY, REPLY ON PINK COPY

GEO-HEAT UTILIZATION CENTER

OREGON INSTITUTE OF TECHNOLOGY – KLAMATH FALLS, OREGON 97601

Ph: 503/882-6321

DIRECTOR
Paul J. Lienau

ASSOCIATE DIRECTORS
Gene Culver
John W. Lund

COORDINATOR
John Smith

RESEARCH ASSOCIATES
Sherman Anderson
Thomas Connors
Leroy Fisk
Charles Higbee
William Johnson
Don Karr
Saul Laskin
Jerry Newcomb
Jay Silva
Larson Svanevik

June 25, 1976

Mr. Lee Campbell
Interstate Pump Co., Inc.
7209 So. 6th St.
Klamath Falls, OR 97601

Dear Mr. Campbell:

As you know, we are conducting a feasibility study to provide heat for City/County governmental buildings from the Museum hot water well.

In order to determine the potential and effect on nearby wells, we discussed with you the possibility of doing a pump test on the Museum well. We would appreciate receiving an estimate and date when the test could be accomplished. Please include in the estimate the costs for pulling and replacing the heating coils, supplying cold water to the well in order to kill the estimated 150 gpm artesian flow, installing a shut-off at the pump and a pipe from pump to the storm sewer catch basin (150 ft. from the well) and run the test for up to 24 hours, depending on the budget.

We would appreciate any suggestions you may have for conducting this test.

Thank you for your cooperation and I look forward to hearing from you soon.

Sincerely yours,

Paul J. Leinau, Director
Geo-Heat Utilization Center

PJL:dts
cc: Mr. Earl Kessler
County Engineer
Courthouse
Klamath Falls, OR

INTERSTATE PUMP COMPANY, INC.
7209 SOUTH SIXTH STREET
KLAMATH FALLS, OREGON
503/882-3464

Date July 9, 1976

SALES ORDER

SOLD TO Oregon Institute of Technology Scheduled Shipping Date

Address Klamath Falls, Oregon 97601 Date

Customer P.O. No. 17491

Ship to: Well Test County Museum hot water well
Name *Address*

Via: Markings

Testing of well at County Museum Hot Water		
100 Ft. 5" column		
24 Hr. Diesel Time @ $25.00 per Hr.	$850.	00
Pull Hot water coils @ $25.00 per Hr. Approx.	250.	00
Replace Hot water coils @ $25.00 per Hr. approx.	250.	00
Fabricated seal for well Approx.	300.	00
TERMS: SALES TAX		
TOTAL PRICE Approx.	$1,650.	00

The Purchaser agrees that any material or labor furnished to him in addition to the above described work shall be charged at current prices and added to and shall become a part of this contract.

The title to and ownership of the property described herein shall remain in the name of the seller, and shall not pass from the seller to the purchaser or to his successors until all purchase money (including deferred payments, notes given for purchase money, and renewals thereof) shall have been fully paid in cash by the purchaser. Said property shall not become a part of any realty, but shall remain the personal property of the seller, regardless of the manner of its use or of its attachment to any realty or other property, until full cash payment is made as aforesaid.

The capacity, speed, lift, and all other service requirements and guarantees and/or warranties herein stated shall be considered as met if it is found the well is crooked to the extent that the mechanical operation of the pump is impaired, or if the well does not properly furnish the pump with the amount of clean, non-areated and/or non-gaseous water, free from sand, detritus and/or other foreign substances, called for herein within the total head or lift specified herein.

It is hereby understood and agreed that all work ordered hereunder is precarious and uncertain in its nature, and all pulling of pumps, reinstalling pumps, repair work, alterations, well work, sand pumping, corrections, or other work herein specified, etc., shall be strictly at the purchaser's risk. The Corporation will not be liable for damage of any kind, particularly including loss or damage for diminuation or failure of crop, shortage of water, inability or failure to supply same, or for diminution or cessation of water flow; nor shall the Corporation be liable for any damages or delays of any kind on account of sticking of pump in the well in any position, either when being pulled out or being reinstated nor shall the Corporation be liable for any damages on account of delay in making repairs or installing by virtue of some defect in the well, or by virtue of the well not being in condition to receive the machinery, or by virtue of unforeseen or changing conditions in the well or in or about the premises on which the well is located.

Time is the essence of this agreement, and should Purchaser fail to make any payment above specified when the same is due, or fail to do anything else required hereunder the entire unpaid balance of the purchase price shall, at the option of Seller, become immediately due and payable and shall bear interest thereafter at the highest lawful rate; and Purchaser agrees to make full payment of such balance. Should Purchaser return said machinery to Seller, or should Seller repossess said machinery, the Seller may retain all payments previously made as compensation for use of said machinery, and Seller may at its option sell said machinery at public or private sale, with or without notice, and credit the net proceeds, after expenses, on the amounts unpaid hereunder. Any balance over the said amounts unpaid hereunder shall be paid to Purchaser on demand. If the net proceeds of such sale are insufficient to cover the amount unpaid hereunder, Purchaser agrees to pay any deficiency upon demand. In lieu of such resale, Seller may, at its option, credit the reasonable value of said machinery as determined by it, less all expenses and attorney's fees herein incurred, as hereinafter provided, to the unpaid amounts due under this contract, in which event Purchaser agrees to pay Seller any difference or deficiency that may exist or remain due or unpaid.

The loss, injury or destruction of said equipment or material shall not operate in any manner to release the undersigned from payment as provided herein. All rights or exemptions and homestead are hereby waived by the undersigned, and the undersigned agrees to pay any and all charges and expenses, including a reasonable attorney's fee, incurred in retaking said material or equipment or in collecting the balance of amount due hereon in case of default. It is expressly agreed that this instrument shall not be countermanded by the undersigned, and covers all agreements between us, all claims of verbal or other agreements between us being waived, and that the acceptance on the part of the seller shall be subject to the approval of its manager and his signature hereon.

Lee Campbell
Salesman

Signed: Paul J. Lueman
Purchaser Director--Geo-Heat

111

NOTE: Price will be "Price in effect at time of delivery."

Signed:
Purchaser

By

Sales

INTERSTATE PUMP COMPANY, INC.

7209 SOUTH 6TH ST. • PHONE 503/882-3464
KLAMATH FALLS, OREGON 97601

Service

- Oregon Institute of Tech.
- Business Office
- Klamath Falls, Oregon 97601

1% per month FINANCE CHARGE applied to past due accounts.
(ANNUAL PERCENTAGE RATE 12%)

DATE	DESCRIPTION	DEBITS		CREDITS		BALANCE	
4-26-75 (11-75)	2331 (R 023445)	2935	62			2935	62
12-18-75	549			2935	62	-0-	
6-24-76	2771	612	50			612	50
7-12-76	4206			612	50	-0-	
8-26-76	2962-B 2:384 (18-262-4023)	73	00			73	00
8-19-76	2940- County Museum	159	55			232	55
8-26	2941- " "	1875	00			2107	55
8-17-76	2331- " "	51	00			2158	55
	Museum Well Pump Test Cost $2,085.55						

LAST FIGURE IN "BALANCE" COLUMN IS AMOUNT DUE

APPENDIX C

MUSEUM WELL PUMP TEST

GEO-HEAT UTILIZATION CENTER

OREGON INSTITUTE OF TECHNOLOGY – KLAMATH FALLS, OREGON 97601

Ph: 503/882 6321

DIRECTOR
Paul J. Lienau

ASSOCIATE DIRECTORS
Gene Culver
John W. Lund

COORDINATOR
John Smith

RESEARCH ASSOCIATES
Sherman Anderson
Thomas Connors
Leroy Fisk
Charles Higbee
William Johnson
Don Kari
Saul Laskin
Jerry Newcomb
Jay Silva
Larson Svanevik

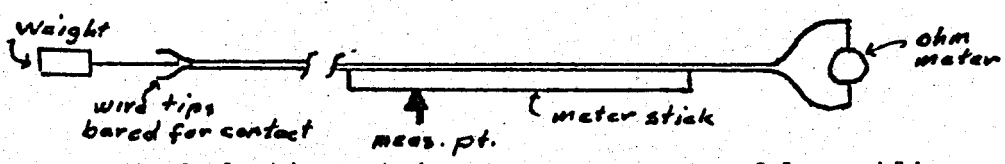
November 24, 1976

Mr. Ed Sammel
Water Resources Division
Branch of Ground Water
Mail Stop 411
Reston, West Virginia 22092

Dear Ed:

Please find enclosed material on the museum well pump test. I apologize for not sending it earlier.

The elevations were taken from a topographic map. John will run a level survey for more accurate elevation values. The drawdown plots are water level changes from t = 0.0 min. A short circuiting ohm meter was used to measure drawdown, giving a scale limit of 1.0 mm. in most cases. Shown below is a sketch of the apparatus:



We feel this technique was very successful, enabling one to make fairly rapid measurements during the initial period of pumping.

The enclosed temperature gradient measurements were made on wells before and after the test.

We are very grateful that USGS is willing to interpret this data.

All of us here at OIT have been very busy finishing up four reports (Klamath Falls Geothermal Mini-Heating District Feasibility Study, Optimization of Geothermal Home Heating Systems, Corrosion on DHE's and County/City District Heating Feasibility Study). In addition ERDA awarded OIT a contract

to study the adaption of geo-heating to the Agri-Business Industry.

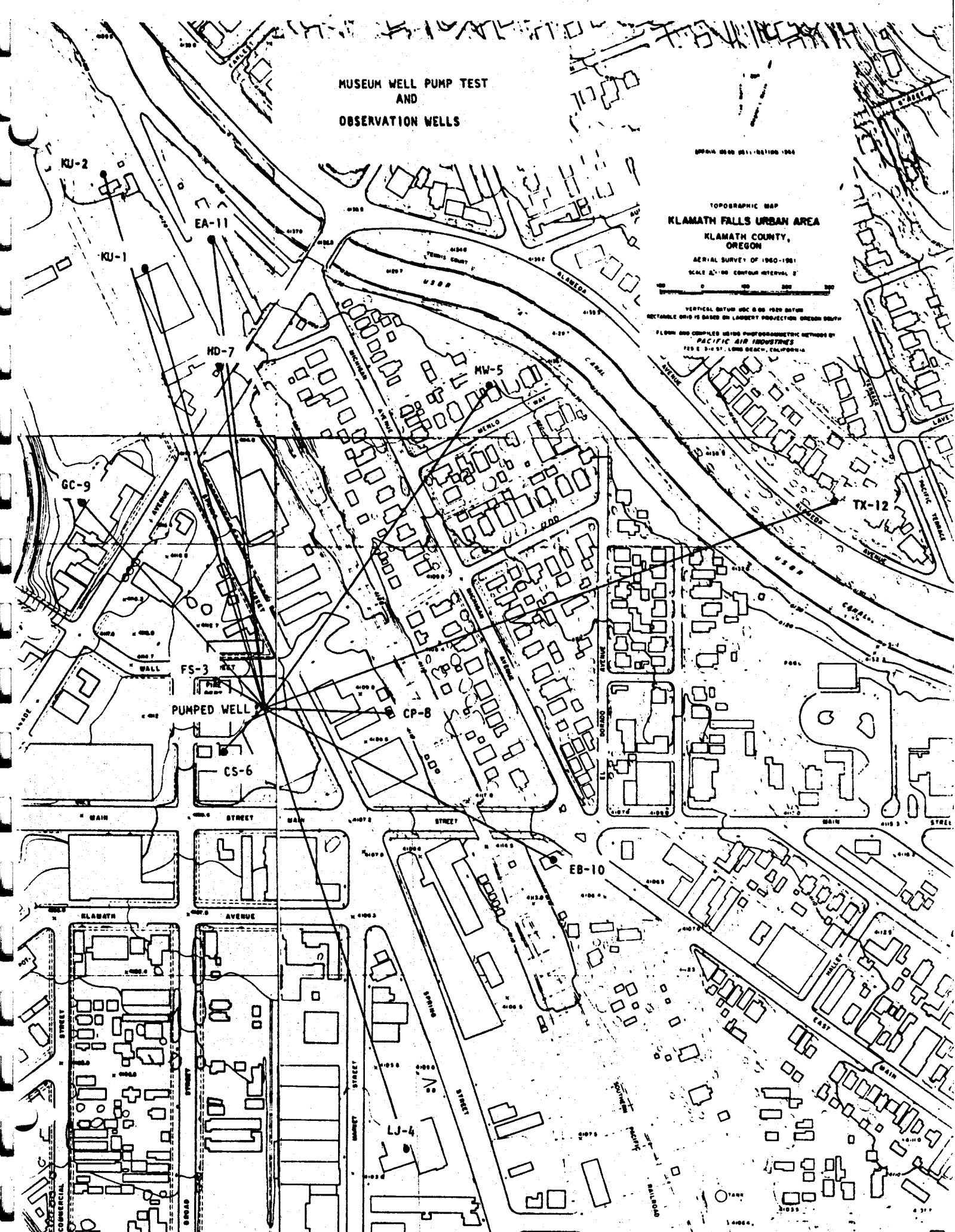
I wish you and your family the best for the coming holidays, and look forward to meeting with you in the near future.

Very truly yours,

Paul

Paul J. Lienau
Director, Geo-Heat Utilization Center

PJL:sef


MUSEUM WELL PUMP TEST
AND
OBSERVATION WELLS
TOPOGRAPHIC MAP
KLAMATH FALLS URBAN AREA
KLAMATH COUNTY,
OREGON
AERIAL SURVEY OF 1960-1961
PACIFIC AIR INDUSTRIES
KU-2
EA-11
KU-1
MD-7
MW-5
GC-9
TX-12
FS-3
PUMPED WELL
CP-8
CS-6
EB-10
LJ-4
MAIN
STREET
KLAMATH
AVENUE
ALAMEDA
RICHMOND
MERLO
WAY
EL DORADO
SPRING
MARKET
BROAD
COMMERCIAL
PACIFIC
RAILROAD
EAST
HALLEY
PACIFIC TERRACE
USBR
CANAL

MUSEUM WELL

Location of Well: Klamath County Museum, Wall Street and Spring Street

Inside Diameter: 10" & 8" Depth: 1,235 feet

450 1/2 feet of 10 inch casing Driller: E. E. Storey and Son Well Drilling, Inc.

150 feet of 5 inch Column and 5 Stage 8 inch Bowls.

Static Water Level at Start of Test: about 150 GPM Artesian.

PUMP TEST DATA

August 4, 1976
10:38 Started test

Elapsed Time (min)	Capacity (GPM)	Drawdown (ft)	Temperature (°F)	Condition of Water (Clear, Muddy, etc.)
0				
7	260	3	186	Clear
22	360	4	183	"
37	360	4	184	"
52	320	4	184	"
67	320	4	184	"
82 (noon)	320	4	182	"
97	310	5	182	"
112	310	4	182	"
127	310	4	182	"
142	460	11 1/2	182	"
157	460	11 1/2	182	"
172	460	11 1/2	182	"
188	470	12	180	"
202	470	11	180	"
217	470	11	182	"
232	470	11	182	"
247	470	11	182	"
252	575	17	180	"
267	670	24	180	"
277	670	24	180	"
292	670	24	182	"
307	670	25	182	"
322	670	25	182	"
352	670	25	182	"
367	670	25	182	"
382	670	27	182	"
397	670	27	182	"
412	670	27	182	"

Elapsed Time (min)	Capacity (GPM)	Drawdown (ft)	Temperature (°F)	Condition of Water (Clear, Muddy, etc.)
427	670	27	182	Clear
442	670	27	184	"
457	670	27	184	"
472	670	27	184	"
487	670	27	184	"
502	670	27	184	"
517	670	27	184	"
532	670	27	184	"
547	670	27	184	"
562	670	27	184	"
577	670	27	184	"
592	670	27	184	"
607	670	27	184	"
622	670	26	184	"
637	670	26	184	"
652	670	26	184	"
667	670	26	184	"
682	670	25	184	"
697	670	25	184	"
712	670	25	184	"
727	670	28	184	"
742	670	28	184	"
757	670	28	184	"
772	670	28	184	"
787	670	28	184	"
802 (mid)	670	28	184	"
817 (am)	670	28	184	"
832	670	28	184	"
847	670	28	184	"
862	670	28	182	"
877	670	28	182	"
892	670	28	182	"
907	670	28	182	"
922	670	28	182	"
937	670	28	182	"
952	670	28	182	"
967	670	28	182	"
982	670	28	182	"
997	670	28	182	"
1012	670	28	182	"
1027	670	28	182	"
1042	670	28	182	"
1057	670	28	182	"
1072	670	28	182	"
1087	670	28	182	"
1102	670	28	182	"
1117	670	28	182	"
1132	670	28	182	"

Elapsed Time (min)	Capacity (GPM)	Drawdown (ft)	Temperature (°F)	Condition of Water (Clear, Muddy, etc.)
1147	670	28	182	Clear
1162	670	28	182	"
1177	670	28	182	"
1192	670	28	182	"
1207	670	28	182	"
1222	670	28	182	"
1237	670	28	182	"
1252	670	28	182	"
1267	670	28	184	"
1282	670	28	184	"
1297	670	28	184	"
1312	670	27	184	"
1327	670	27	184	"
1342	670	27	184	"
1357	670	27	184	"
1372	670	27	184	"
1387	670	27	184	"
1402	670	27	184	"
1417	670	27	184	"
1432	670	27	184	"
1447	670	27	184	"
1462	670	27	184	"
1477	670	27	184	"
1492	670	27	184	"
1507(noon)	670	27	184	"
1522(pm)	670	27	184	"
1537	670	27	184	"
1652	670	27	184	"
1667	670	27	184	"
1682	670	27	184	"
1697	670	27	184	"
1712	670	27	184	"
1727	670	27	184	"
1742	670	27	184	"
1757	670	27	184	"
29.28 Hours Total Test				

PJL:sef

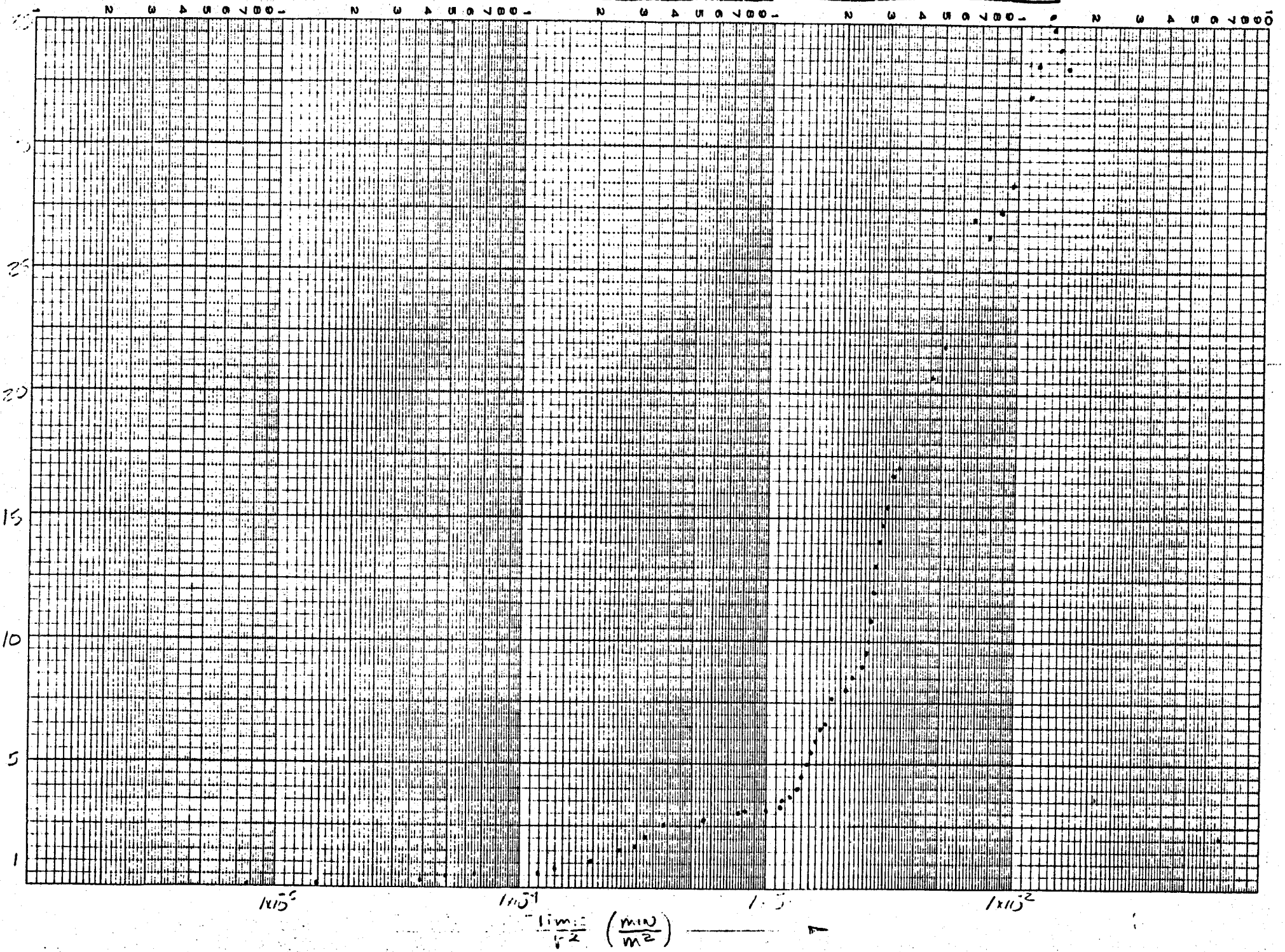
Observation Well Data
Resulting from Museum Well Pump Test
(Pumped Well began discharging 320 gal min^{-1} @ t=0 min.
470 gal min^{-1} @ t=136.2 min and 670 gal min^{-1} @ 249.0 min.
and shutdown @ t=1704 min.)

WELL NO.	DISCRIPTION	WELL DEPTH (ft) / BOTTOM TEMP. (°C)	DISTANCE TO PUMPED WELL (ft)	ELEVATION (ft)	WATER LEVEL FROM MEAS. PT. t=0.0 min. (cm)	DRAWDOWN t=1704 min. (cm)	MEASUREMENT PROBLEMS
KU-1	Klamath Union H.S. Recharge well.	240 / 58.8	1070	4116 ± .1	159.0	33.2	none
KU-2	Klamath Union H.S. Production Well	257 / 73.3	1305	4121 ± .5	415.4	38.1	Oil is used to break the air/water interface. This oil interface caused difficulty with our measuring instrument, thus resulting in the scattering pts. on the plot.
FS-3	Fire Station well pumped and returned to same well @ Broad and Wall. A cable tool bit is at the well bottom.	260 / 64.2	129	4113 ± .3	96.9	116.9	none
LJ-4	Lowell Jone's well is pumped and used to heat two commercial buildings @ 310 S. Spring Street.	499 / 64.2	1087	4104.5 ± .3	196.5	32.5	none

WELL NO.	DISCRIPTION	WELL DEPTH (ft) / BOTTOM TEMP. (°C)	DISTANCE TO PUMPED WELL (ft)	ELEVATION	WATER LEVEL FROM MEAS. PT. t=0.0 min. (cm)	DRAWDOWN t=1704 min. (cm)	MEASUREMENT PROBLEMS
MW-5	Well location at 1737 Menlo Way and is used to heat a house by DHE method.	228 / 84.7	924	4119.5 ± .3	183.0	26.2	none
CS-6	Well located inside Carpet Shop and is pumped to heat shop @ 1409 Main Street.		123.0	4109.5 ± .3	92.8	28.3	Difficult to measure due to small opening. Ref. pt. was moved during test.
HD-7	Highway Dept. well with DHE used to heat highway pavement.	310 / 56.3	810	4113 ± .05	141.3	47.2	Passing trains caused a 0.2 cm reading flucuation.
CP-8	Coke Plant Well is pumped to heat commercial building @ 105 N. Spring St.	316 / 57.6	283	4108.8 ± .05	72.0		Pump was turned off 24 hrs. prior to test resulting in water rising to fill head pit. Some measurements were made of this water level from a reference pt.

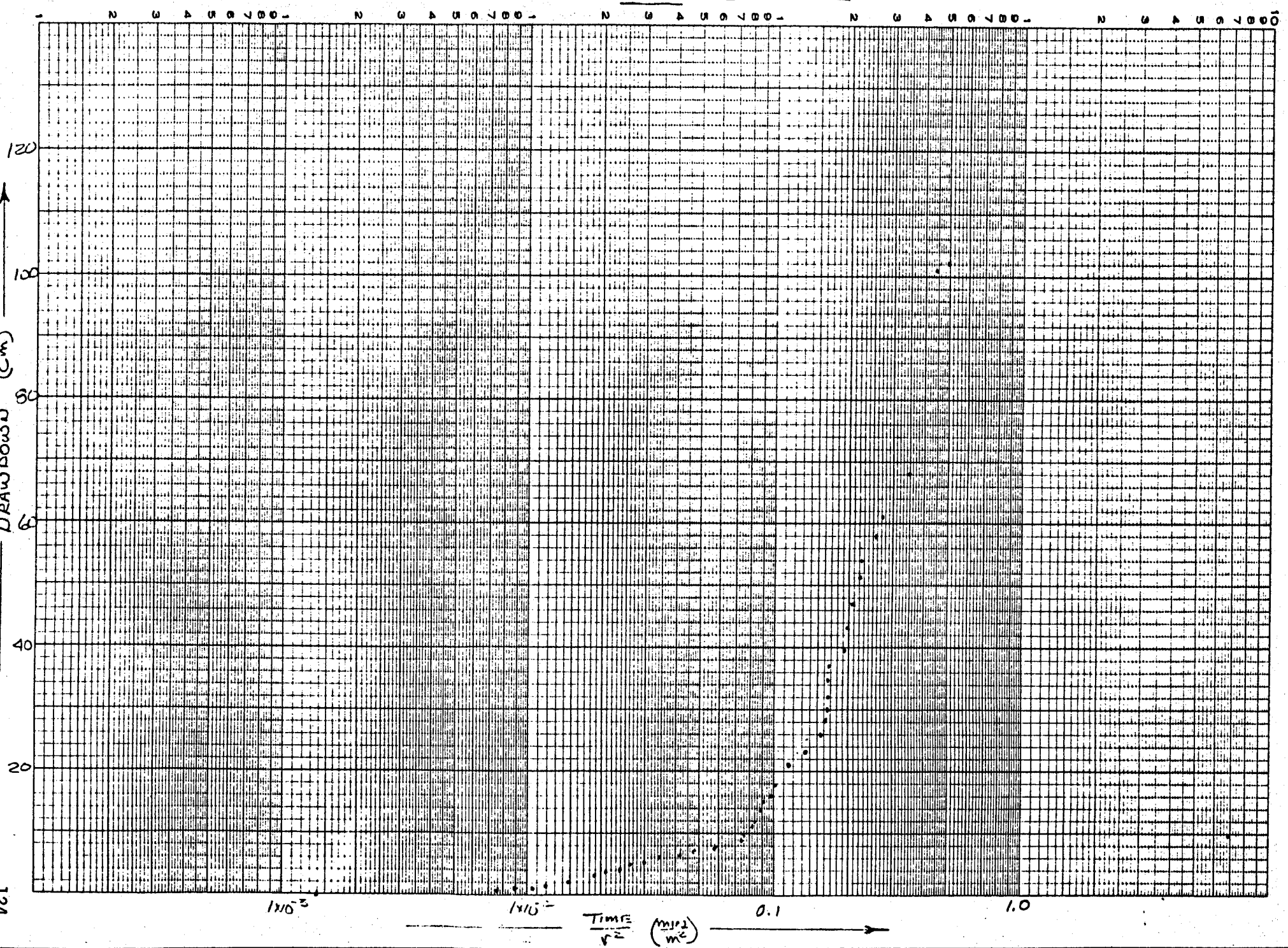
WELL NO.	DISCRIPTION	WELL DEPTH (ft) / BOTTOM TEMP. (°C)	DISTANCE TO PUMPED WELL (ft)	ELEVATION	WATER LEVEL FROM MEAS. PT. t=0.0 Min. (cm)	DRAWDOWN t=1704 min. (cm)	MEASUREMENT PROBLEMS
GC-9	Garrison Clinic well is pumped to heat clinic @ 1437 Esplanade St.	248 / 68.9	640	4118.9 ± .1	84.6	53.0	none
EB-10	Artesian well located inside building @ 120 East Main St.	900 / 85.4	758	4108.0 ± .2	Artesian	22.4	Artesian flow ceased during test. The well rebounded back to artesian flow in 7.0 min. after shutdown.
EA-11	Esplanade Apt. well is abandon-ed.	128 / 41.8	1105	4120.5 ± .3	167.6	4.0	Well may have part-ially caved in. Ran-dom meas. were made on the well during the test.
TX-12	Thexton's well is used to heat a home by pump-ed method @ 235 North Alameda.	256 / 75.3	1425	4138.0 ± .1	475.5	9.9	The well pump went on during a portion of the test.

NO. 340-L510 DIETZGEN GRAPH PAPER
S LOGA IC
5 CYCLES X 10 DIVISIONS PER INCH
EUGENE DIETZGEN CO.
ADE A.



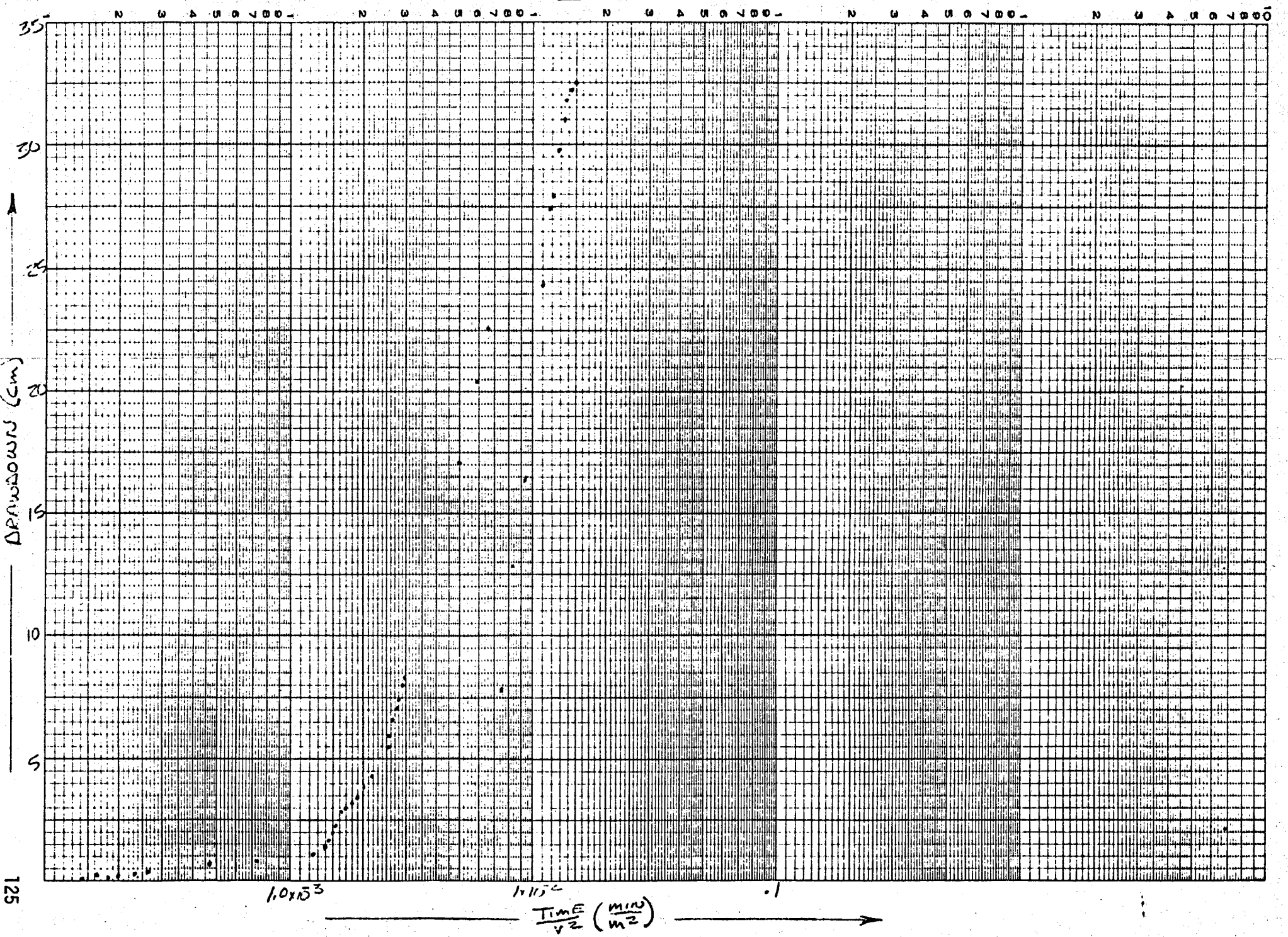
NO. LS1 TZGE IAPH R NE D EN D
SEMI-LOGARITHMIC
5 CYCLES X 10 DIVISIONS PER INCH
MADE IN U. S. A.

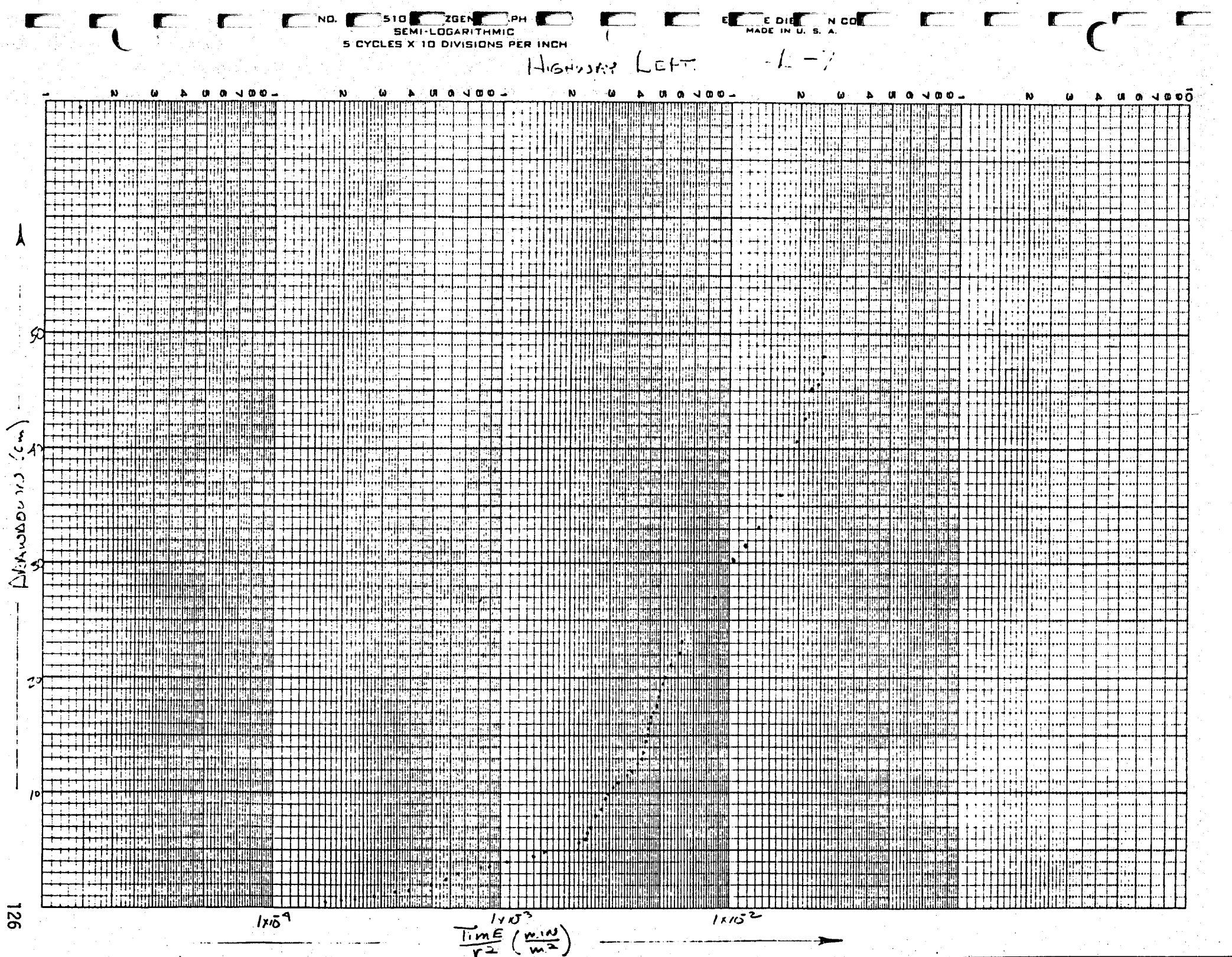
FIRE STATION



NO. 340-L510 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
5 CYCLES X 10 DIVISIONS PER INCH
EUGENE DIETZGEN CO.
MADE IN U.S.A.

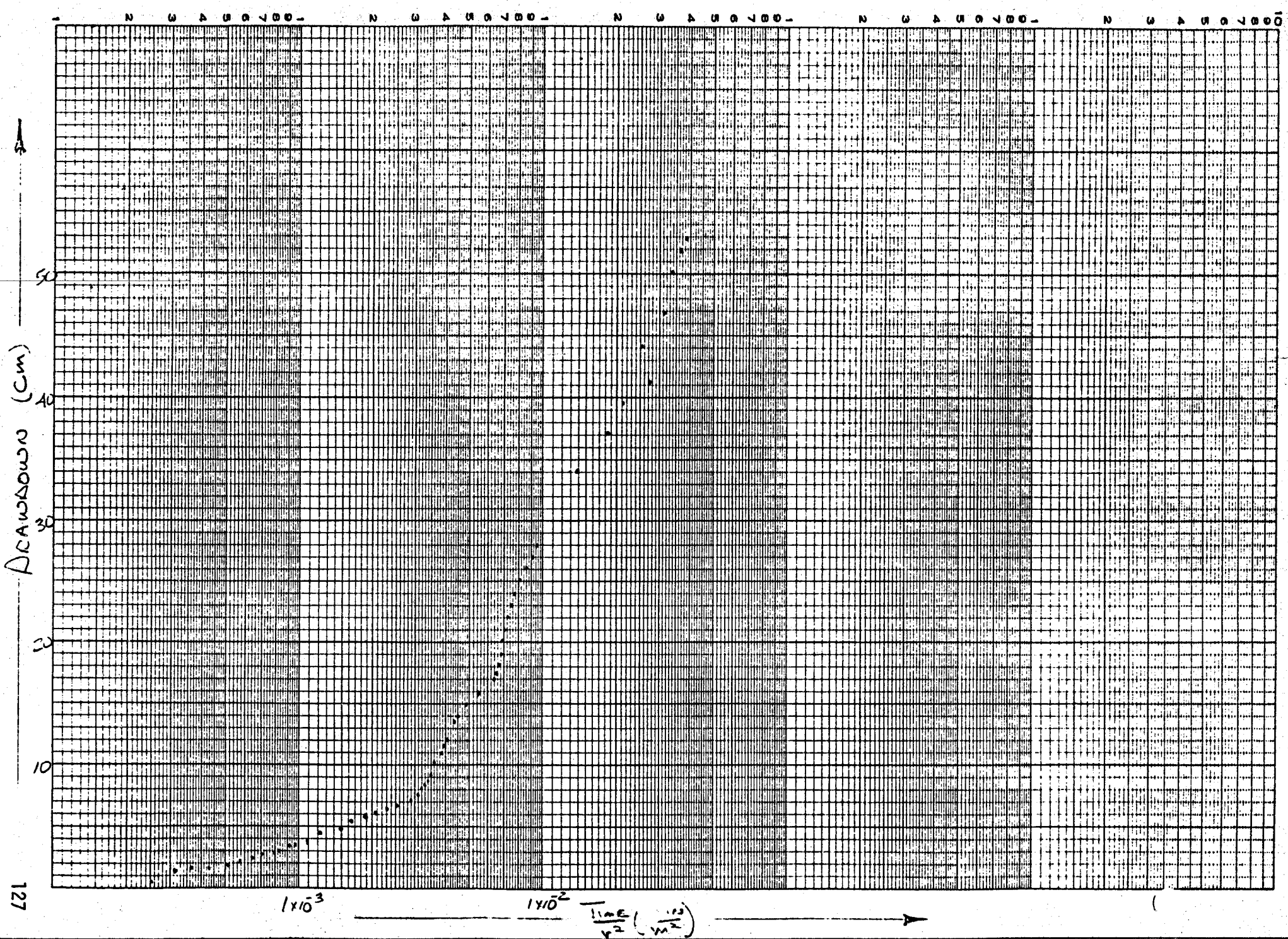
LOWELL JONES LOGGING




ND. 510 ZGEN PH
SEMI-LOGARITHMIC
5 CYCLES X 10 DIVISIONS PER INCH
E DIE N CO
MADE IN U. S. A.
HIGHWAY LEFT
50
40
30
20
10
DEFLECTION (cm)
1x10^-4
1x10^-3
1x10^-2
TIME / r^2 (min/m^2)

NO. L510 TZGE APH R NE D EN C
SEMI-LOGARITHMIC
5 CYCLES X 10 DIVISIONS PER INCH
MADE IN U. S. A.

GC-9



GEOTHERMAL WELL DATA

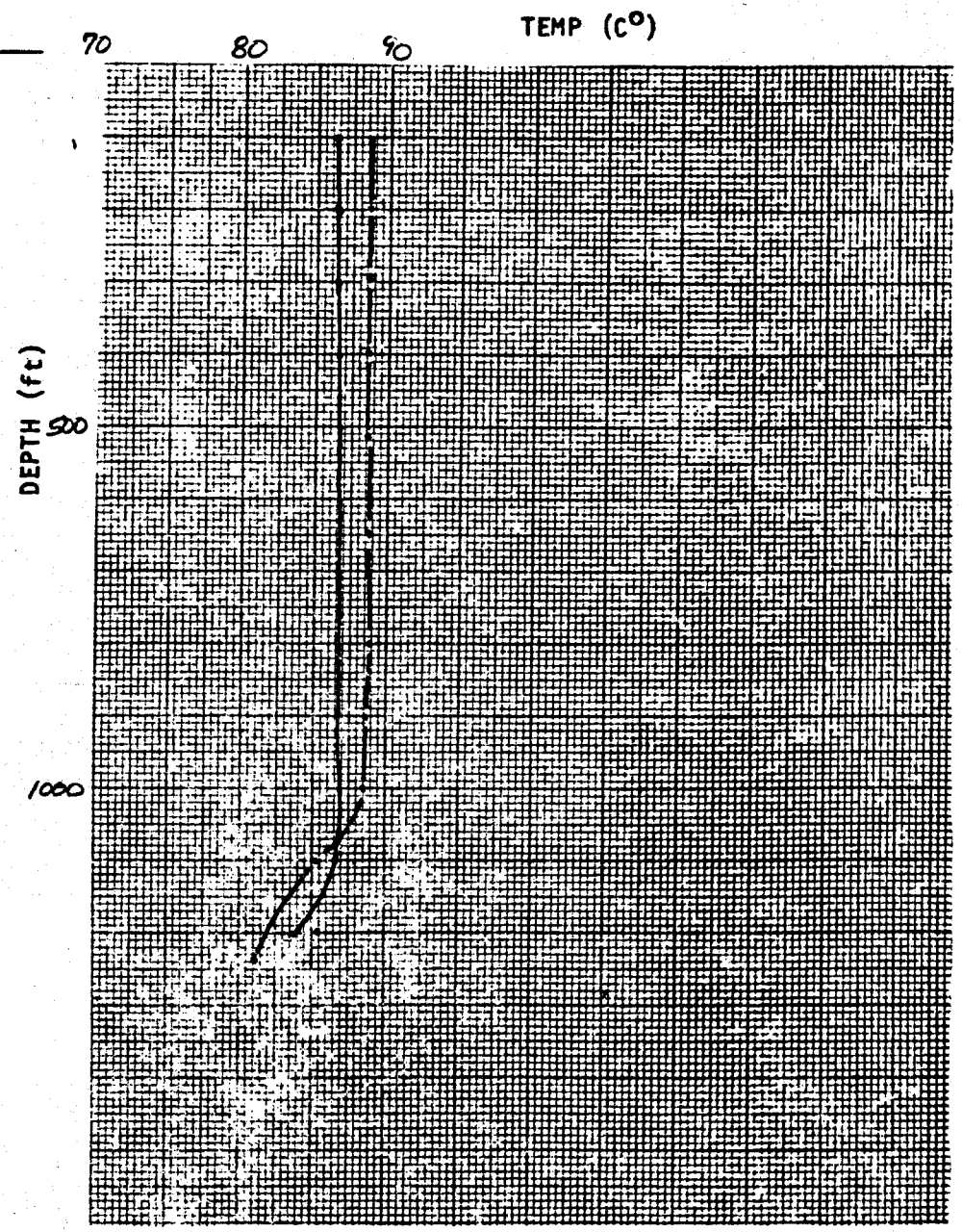
Temperature Log Pumped Well

Location: 1451 MAIN STREET Owner: KLAMATH COUNTY MUSEUM

Well Characteristics: Artesian (0 = 15 GPM)

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
Date:		8/3/76	8/6/76				
SWL:		N/A	N/A				
1.	100	86.4	88.6				
2.	200	86.5	88.6				
3.	300	86.5	88.6				
4.	400	86.6	88.6				
5.	500	86.6	88.6				
6.	600	86.7	88.7				
7.	700	86.7	88.7				
8.	800	86.7	88.9				
9.	900	86.7	88.7				
10.	1000	86.8	88.5				
11.	1100	86.6	85.4				
12.	1200	83.7	85.4				
13.	1235*		81.2				
14.							

*Bottom



GEOTHERMAL WELL DATA

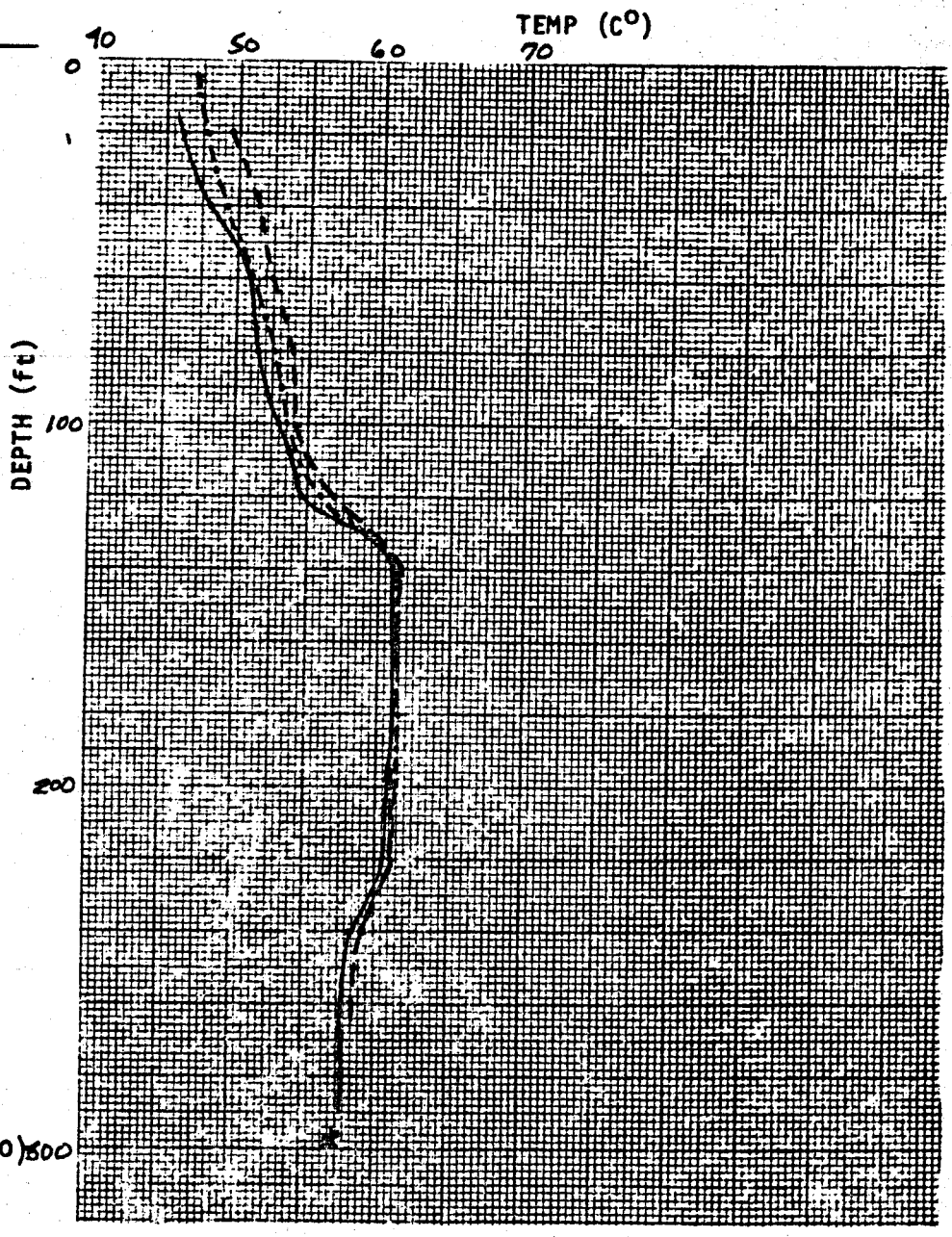
Temperature Log KU-1

Location: RETURN WELL #1 Owner: KLAMATH UNION HIGH SCHOOL

Well Characteristics:

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
Date:		8/3/76	8/5/76	8/20/76			
SWL:		3.5 ft.		4.1 ft.			
1.	20	46.2	49.6	47.8			
2.	40	48.1	51.4	49.2			
3.	60	50.4	52.4	50.9			
4.	80	51.5	53.9	52.6			
5.	100	53.0	54.2	53.6			
6.	120	54.6	56.9	55.9			
7.	140	61.0	61.5	61.2			
8.	160	61.2	61.3	61.5			
9.	180	61.1	61.2	61.4			
10.	200	60.9	61.1	61.6			
11.	220	60.7	61.1	61.1			
12.	240	58.4	59.1	58.8			
13.	280	57.8	58.4				
14.	333*	57.5					

*Bottom 8/20/76 Bottom = 240.2 ft. SWL = 4.1' & 47.2(CO)
8/5/76 Bottom = 315.9 ft.



GEOTHERMAL WELL DATA

Temperature Log KU-2

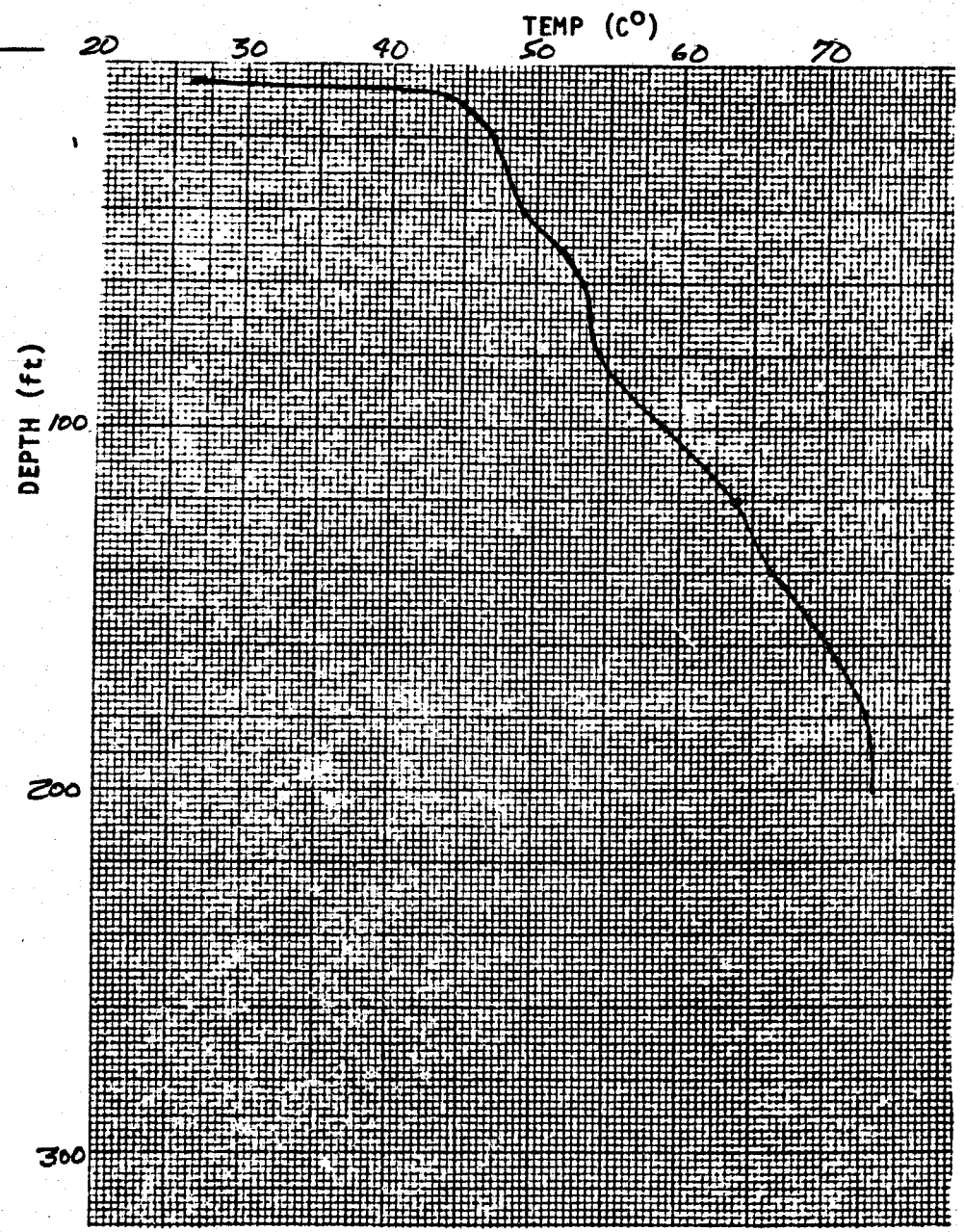
Location: PRODUCTION WELL #2 Owner: KLAMATH UNION HIGH SCHOOL

Well Characteristics: Oil on water surface

Date: 8/3/76

SWL: 4.3 ft.

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
1.	5	26.4					
2.	20	47.0					
3.	40	48.9					
4.	60	53.2					
5.	80	54.5					
6.	100	59.1					
7.	120	63.8					
8.	140	66.3					
9.	160	70.1					
10.	180	72.9					
11.	200	73.4					
12.							
13.							
14.							



GEOTHERMAL WELL DATA

Temperature Log FS-3

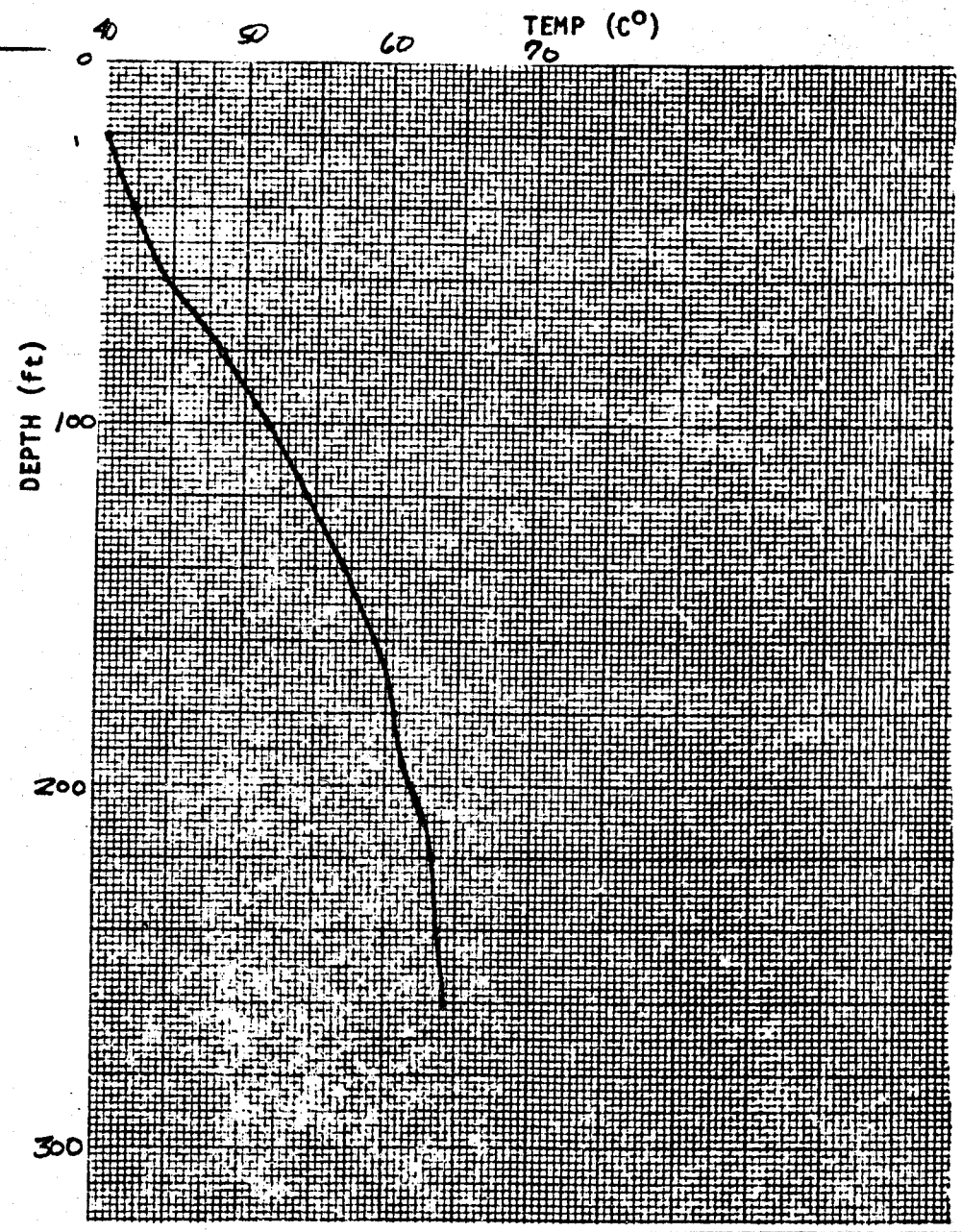
Location: BROAD STREET Owner: CITY FIRE HALL

Well Characteristics:

Date: 6/30/76

SWL: 2'

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
1.	20	40.5					
2.	40	42.5					
3.	60	44.4					
4.	80	48.5					
5.	100	51.5					
6.	120	54.3					
7.	140	57.0					
8.	160	59.2					
9.	180	60.6					
10.	200	61.8					
11.	220	63.3					
12.	240	63.7					
13.	260	64.2					
14.							



GEOTHERMAL WELL DATA

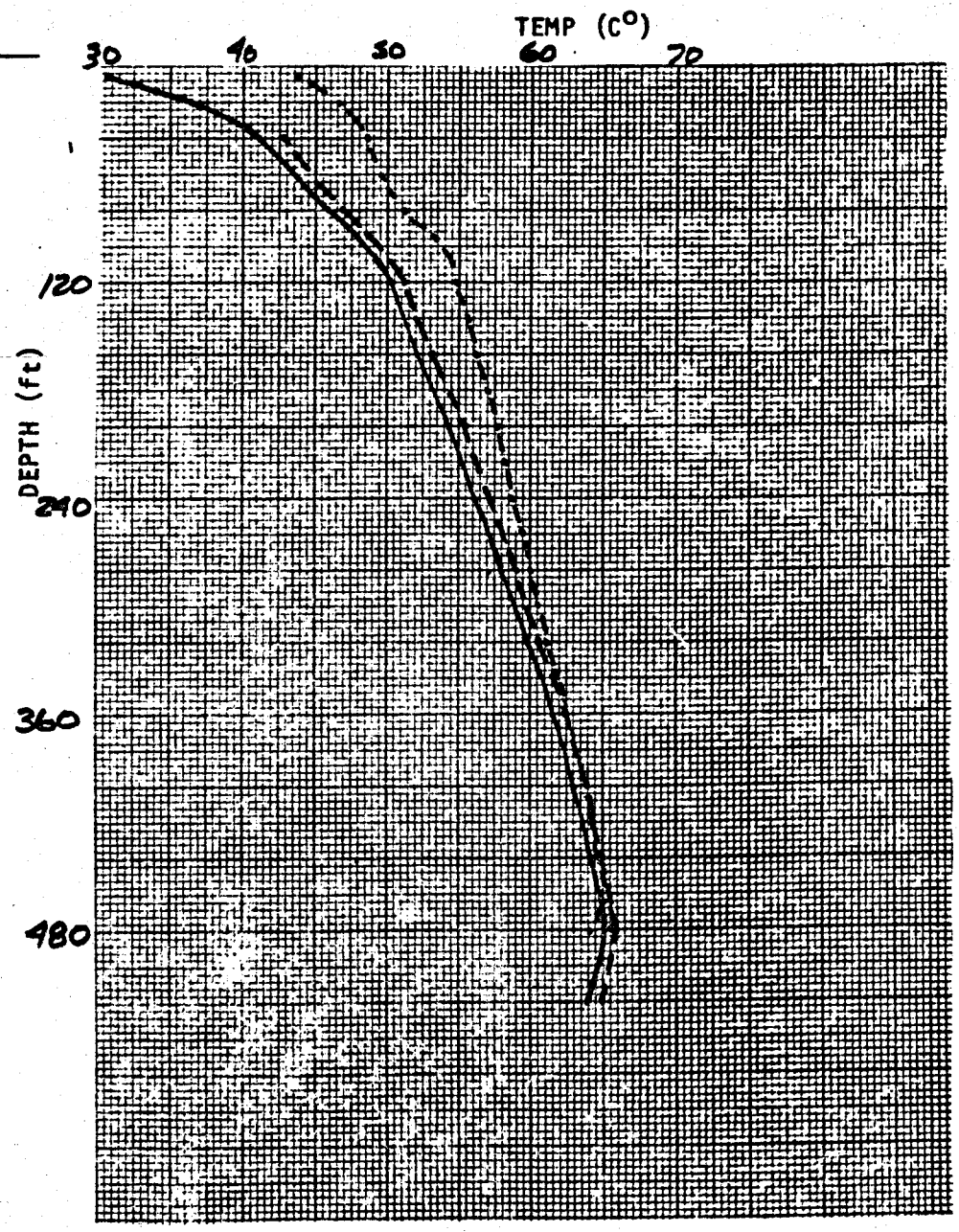
Temperature Log LJ-4

Location: 310 SPRING STREET Owner: LOWELL JONES LOGGING

Well Characteristics: _____

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
Date:		7/12/76	8/5/76	8/20/76			
SWL:		4.5 ft.		4.9 ft.			
1.	SWL	30.9		43.7			
2.	40	42.3	42.8	48.5			
3.	80	45.8	46.7	51.2			
4.	120	50.2	51.1	54.7			
5.	160	52.2	53.2	56.2			
6.	200	54.3	55.4	57.6			
7.	240	56.1	57.1	58.8			
8.	280	57.8	58.9	59.9			
9.	320	59.7	60.6	61.0			
10.	360	61.5	62.4	61.9			
11.	400	63.0	63.8	63.7			
12.	440	64.1	64.9	64.5			
13.	480	65.2	65.8	65.4			
14.	520	63.9	64.7	64.2*			

* Bottom @ 499.4



GEOTHERMAL WELL DATA

Temperature Log MW-5

Location: 1737 MENLO WAY Owner: RESIDENCE

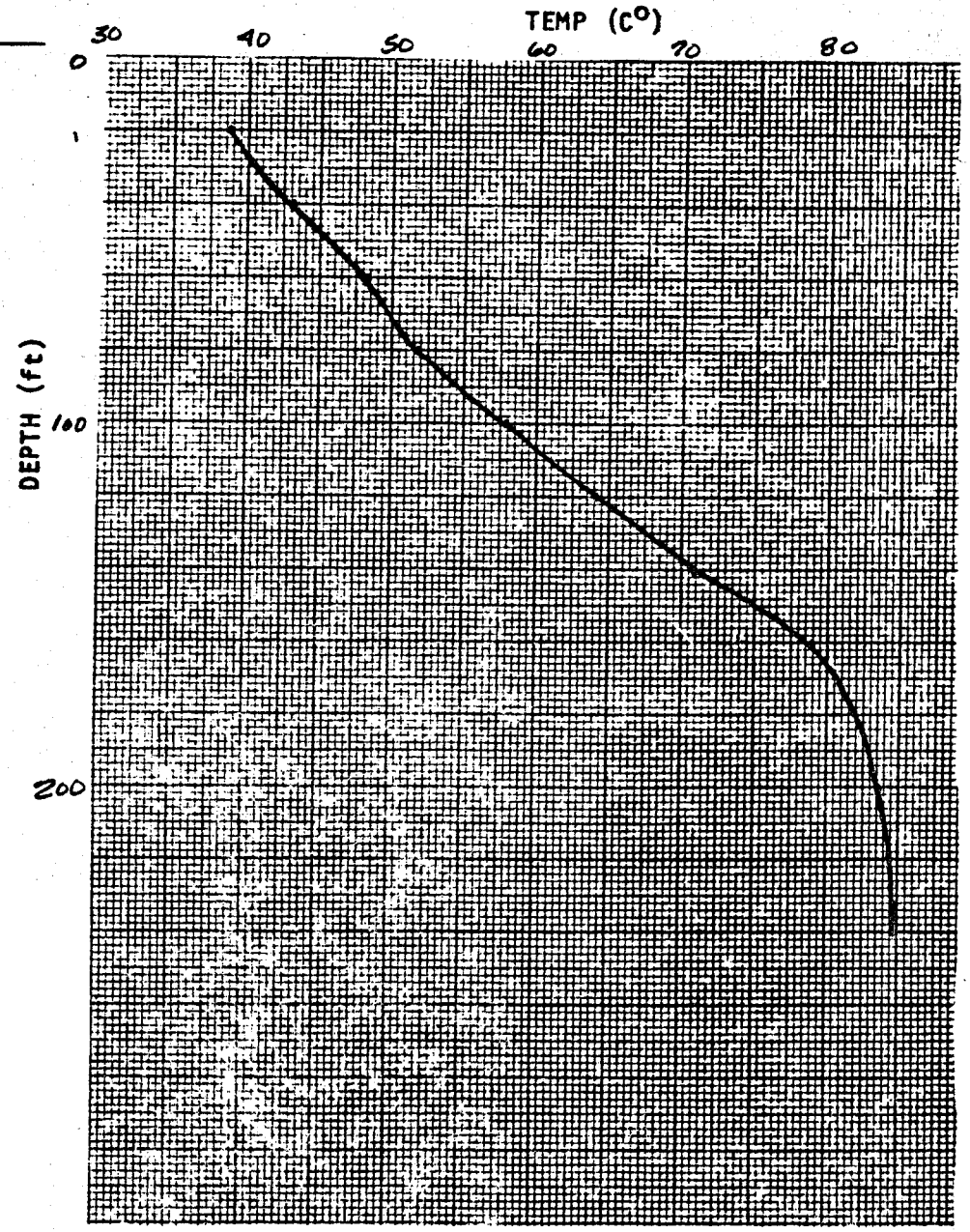
Well Characteristics: Depth = 213'4"

Date: 8/5/76

SWL: 3 ft.

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
1.	20	38.8					
2.	40	43.1					
3.	60	48.3					
4.	80	52.7					
5.	100	57.9					
6.	120	64.1					
7.	140	70.8					
8.	160	78.9					
9.	180	82.8					
10.	200	83.5					
11.	220	84.4					
12.	228*	84.7					
13.							
14.							

*Bottom



GEOTHERMAL WELL DATA

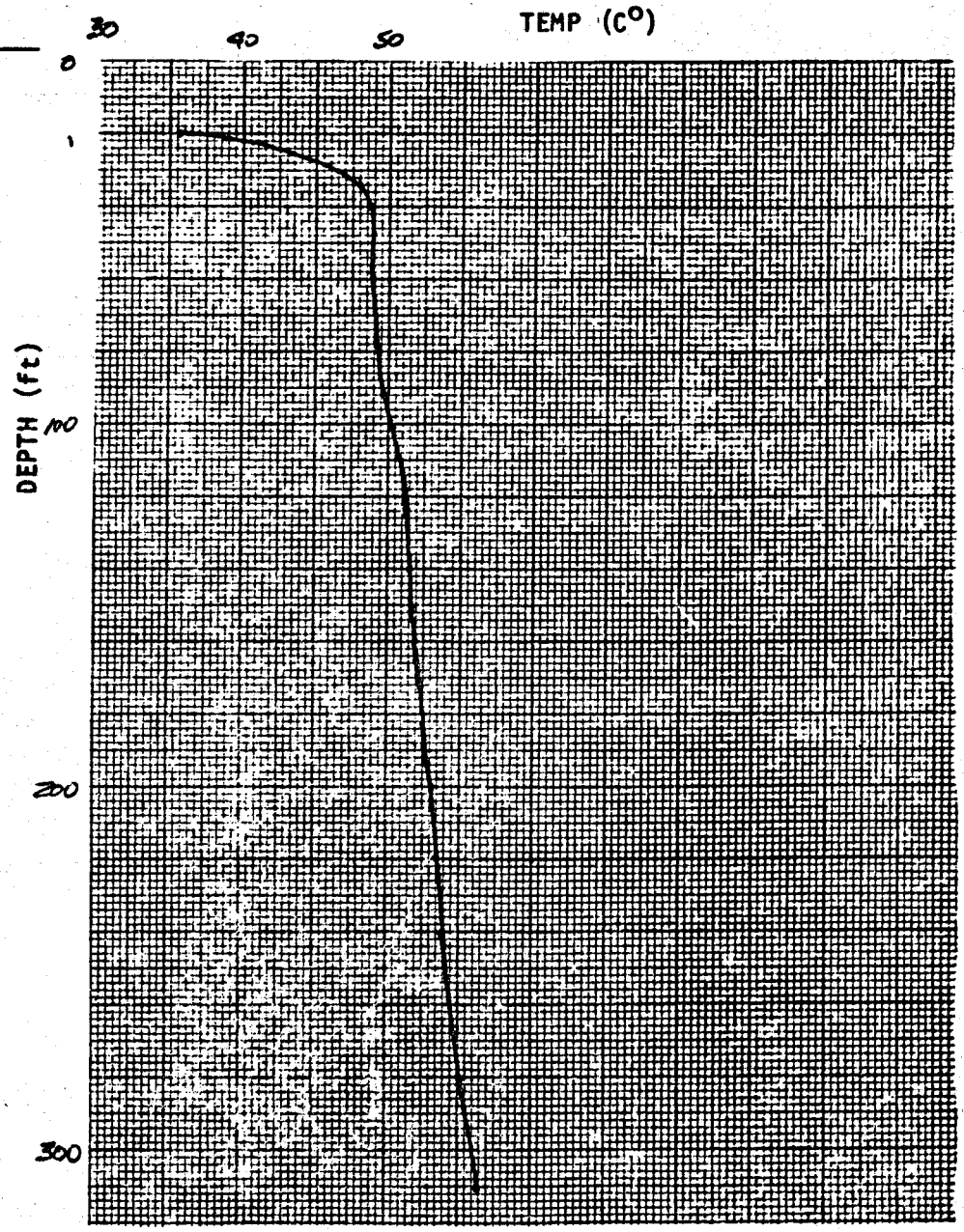
Temperature Log HD-7

Location: ESPLANADE & R.R. OVERPASS Owner: OREGON STATE HIGHWAY DEPARTMENT

Well Characteristics: 10" Casing to 307'

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
Date:		8/5/76					
SWL:							
1.	20	35.6					
2.	40	48.7					
3.	60	48.9					
4.	80	49.3					
5.	100	50.1					
6.	120	51.1					
7.	140	51.5					
8.	160	52.0					
9.	180	52.5					
10.	200	53.2					
11.	220	53.5					
12.	240	53.9					
13.	280	55.1					
14.	310*	56.3					

*Bottom



GEOTHERMAL WELL DATA

Temperature Log CP-8

Location: 105 NORTH SPRING Owner: COCA-COLA BOTTLING COMPANY

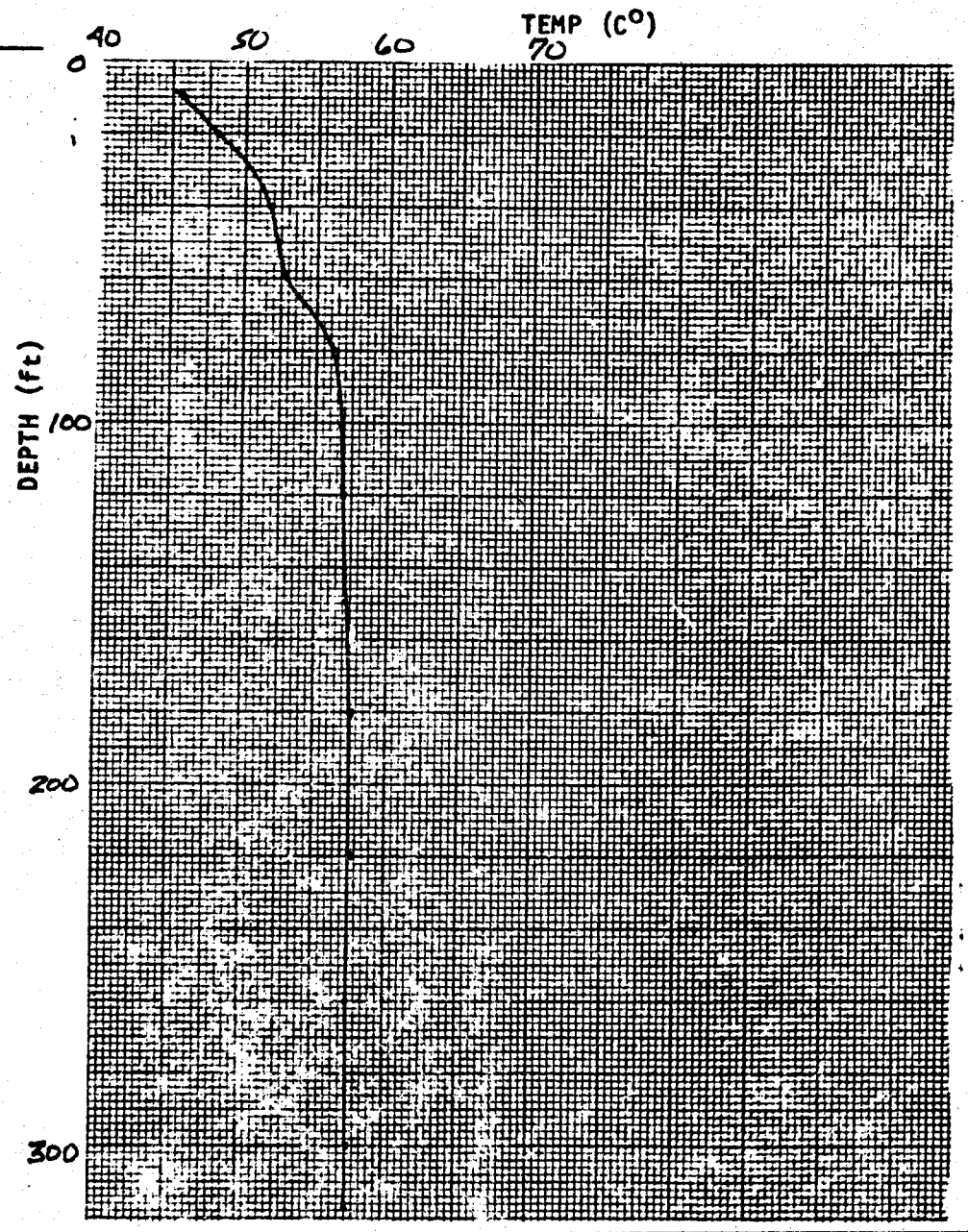
Well Characteristics: 10" Casing; Pumped (Q = 10 GPM)

Date: 6/30/76

SWL: 8.8 ft.

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
1.	SWL	45.6					
2.	20	48.1					
3.	40	51.7					
4.	60	52.9					
5.	80	56.4					
6.	100	56.7					
7.	120	57.0					
8.	140	57.2					
9.	180	57.6					
10.	220	57.6					
11.	260	57.5					
12.	300	57.6					
13.	3165*	57.6					
14.	340	57.7					

*Bottom



GEOTHERMAL WELL DATA

Temperature Log GC-9

Location: ESPLANADE STREET Owner: GARRISON CLINIC

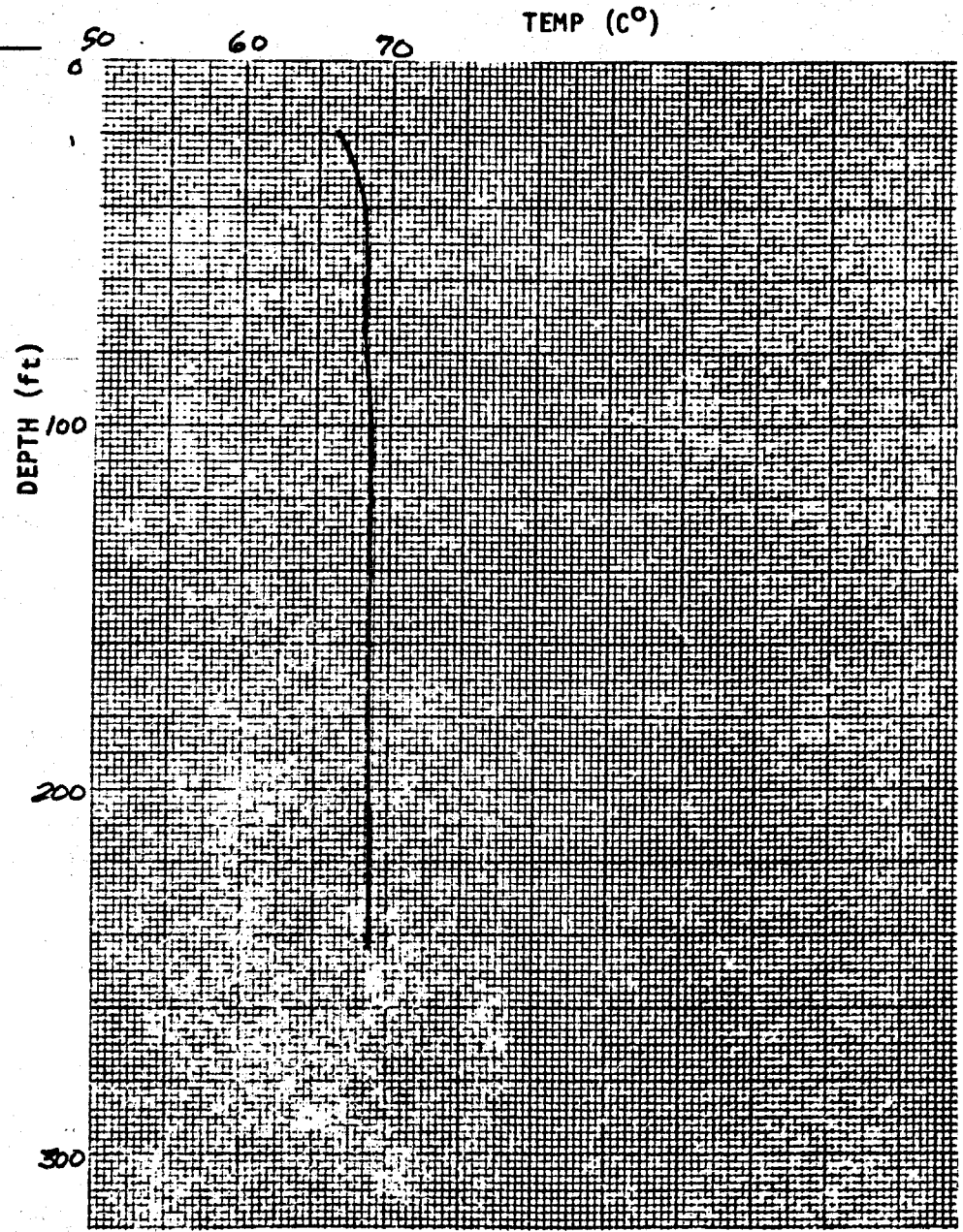
Well Characteristics:

Date: 3/2/76

SWL: ?

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
1.	20	66.3					
2.	40	68.2					
3.	60	68.3					
4.	80	68.3					
5.	100	68.6					
6.	110	68.6					
7.	140	68.6					
8.	160	68.7					
9.	180	68.7					
10.	200	68.7					
11.	220	68.7					
12.	240	68.7					
13.	248*	68.9					
14.							

* Bottom



GEOTHERMAL WELL DATA

Temperature Log EB-10

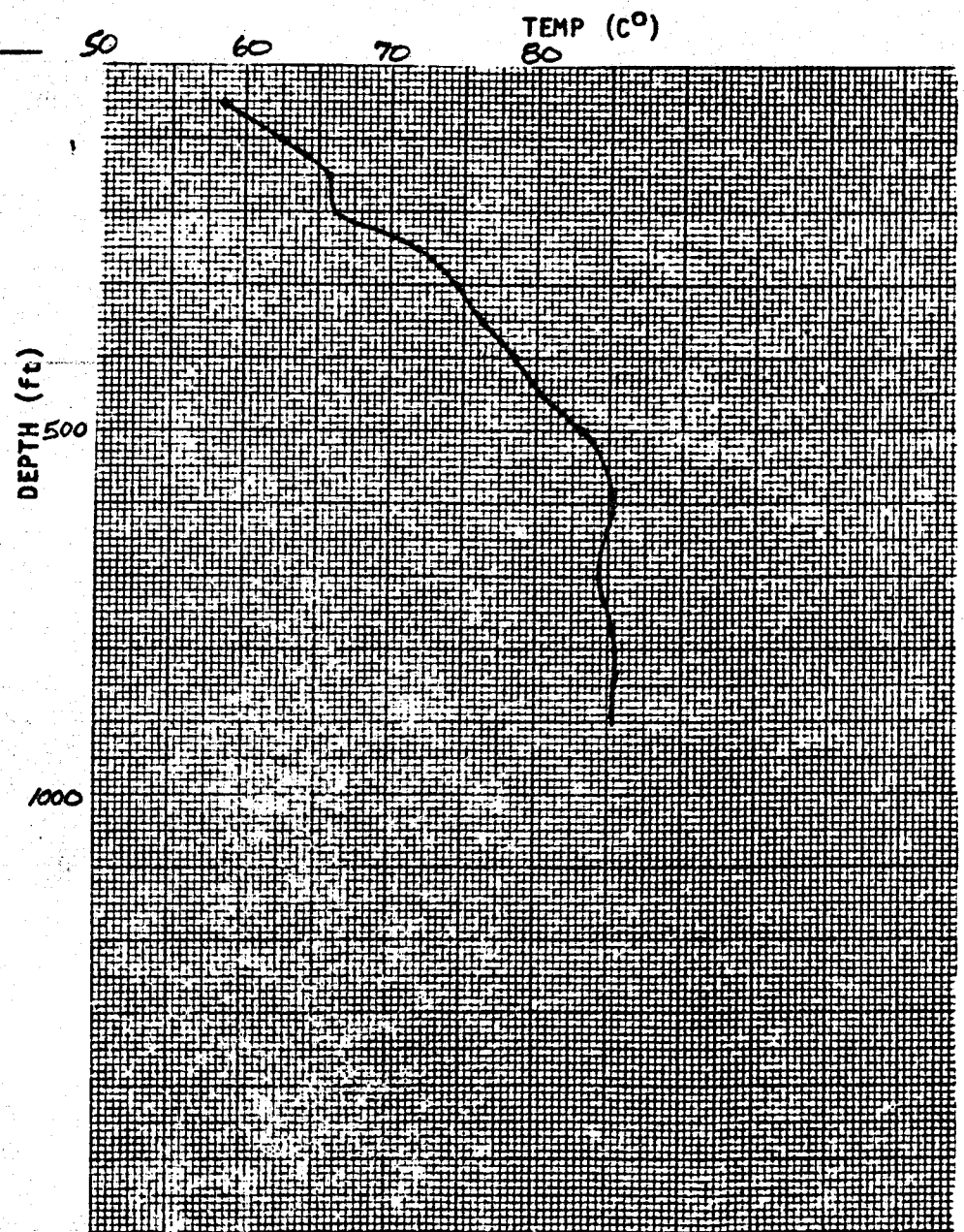
Location: EAST MAIN and MAIN Owner: EZELL

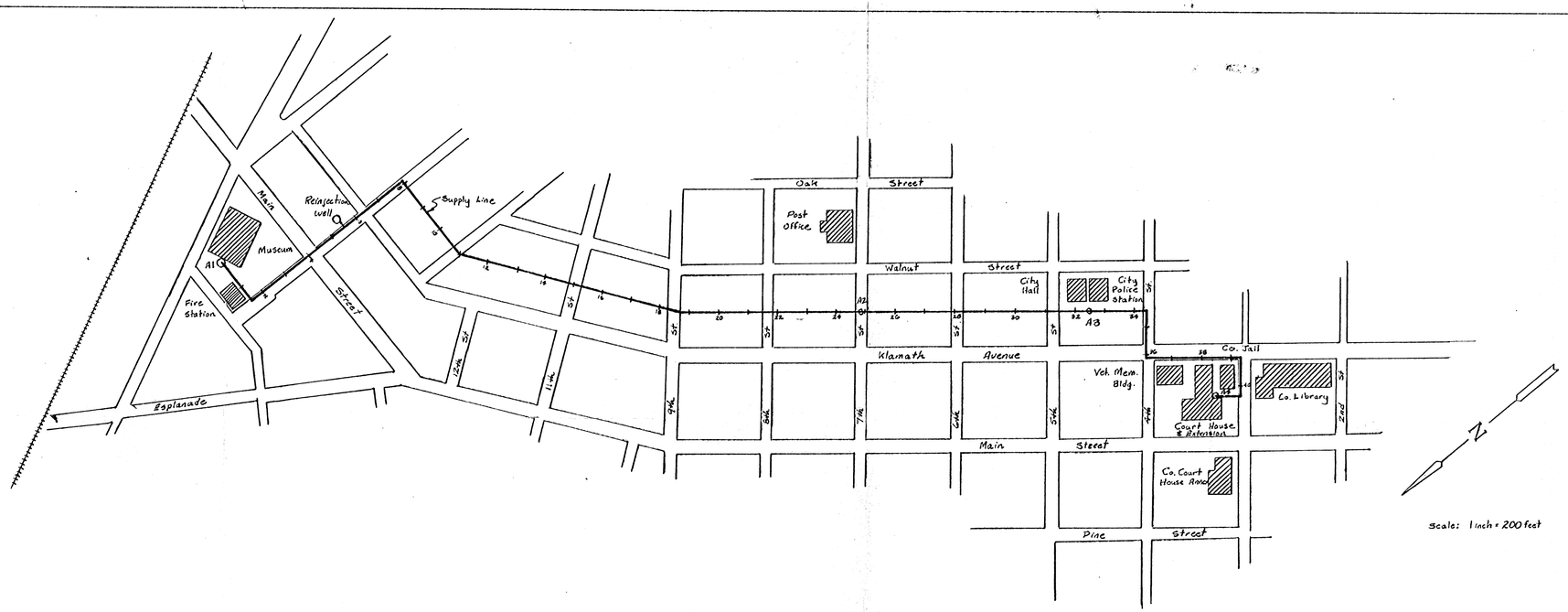
Well Characteristics: Artesian

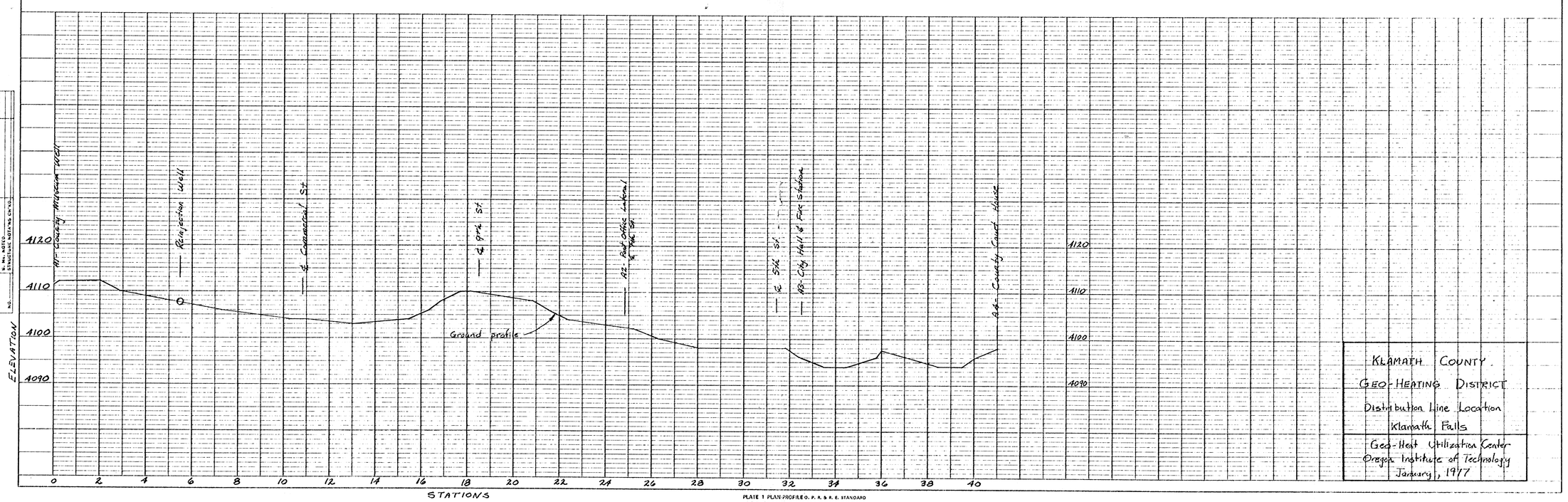
Date: 8/5/76

SWL:

	DEPTH (ft)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)	Temp (C°)
1.	50	58.5					
2.	100	62.3					
3.	150	65.9					
4.	200	66.2					
5.	250	71.9					
6.	300	74.6					
7.	350	76.3					
8.	400	78.5					
9.	450	80.3					
10.	500	83.1					
11.	600	85.4					
12.	700	84.4					
13.	800	85.5					
14.	900	85.4					







KLAMATH COUNTY
GEO-HEATING DISTRICT
Distribution Line Location
Klamath Falls

Geo-Heat Utilization Center
Oregon Institute of Technology
January, 1977

PLATE 1 PLAN-PROFILE O. P. A. & A. E. STANDARD
100% RAG PAPER - MADE AND PRINTED IN U.S.A.
EUGENE DIETZGEN CO.

PLAN		BY	DATE
NOTE BOOK	SURVEYED		
	PLOTTED		
	ALIGNMENT CHECKED		
	NO. OF SHEETS		
NO.			

PROFILE		BY	DATE
NOTE BOOK	SURVEYED		
	PLOTTED	I. LUND	10/27/76
	CHECKED		
	B. MARK ELEVATION		
NO.	STRUCTURE NOTE NO. ON NO.		