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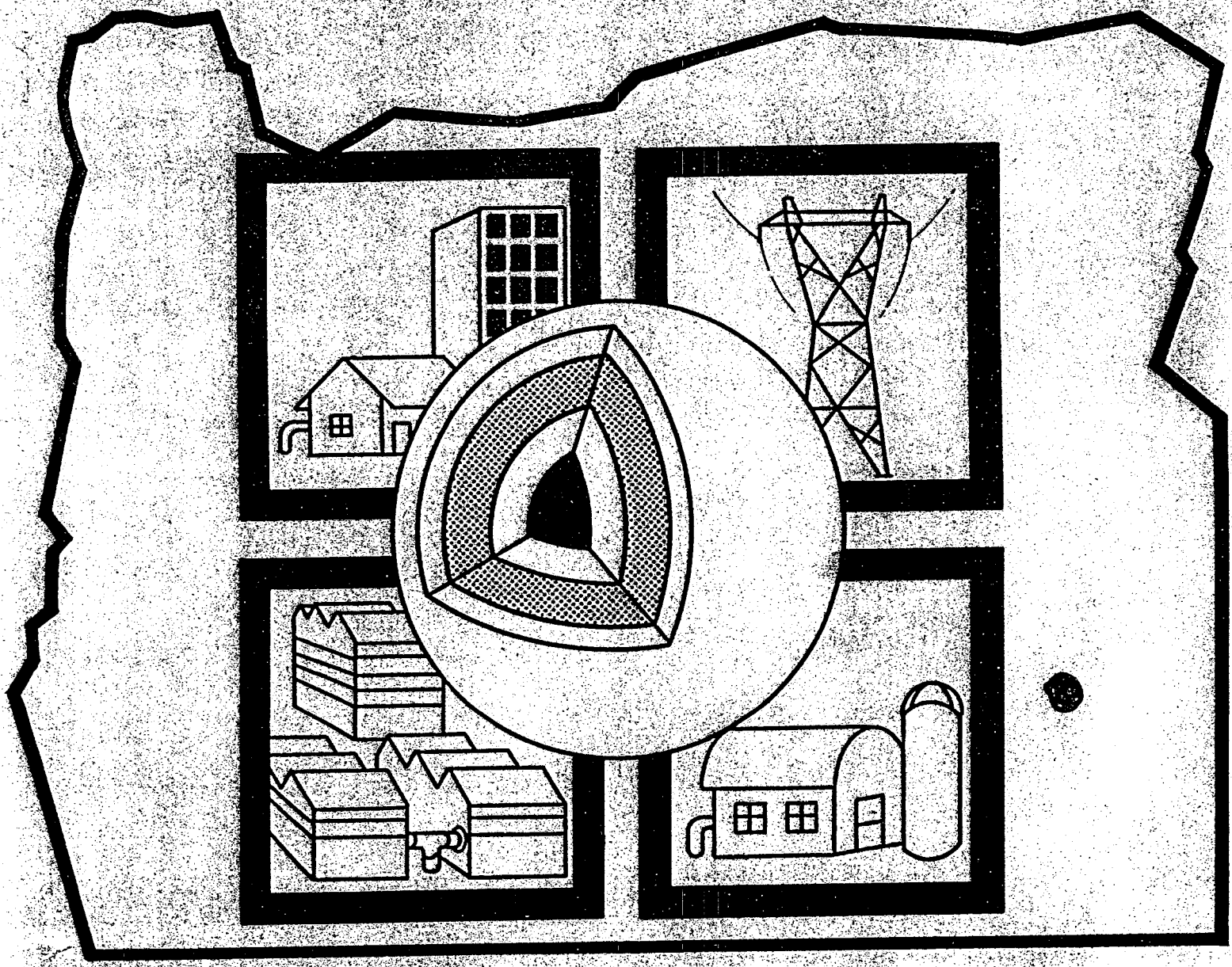
CONF-80-002

Paul Jewell

OREGON



GEOTHERMAL

CONFERENCE

OCTOBER 2, 1980

DISCLAIMER

PROGRAM

OREGON GEOTHERMAL PLANNING CONFERENCE

October 2, 1980
Bend, Oregon

I. REGISTRATION

* Deschutes Room, The Riverhouse — 8:30-9:00

II. MORNING SESSION: Moderator, Debra Justus, O.I.T. Geoheat Center

* Welcome & Opening Remarks: The Oregon Geothermal Planning Program; David Philbrick, Oregon Department of Energy — 9:05-9:15

* Geothermal Introduction:

  - The nature and occurrence of the resource, and exploration and drilling techniques; Dr. John Lund, O.I.T. Geoheat Center — 9:15-9:35

  - Nature and occurrence of the resource in Oregon, and status of Oregon assessment programs; Norm Peterson, Oregon Department of Geology & Mineral Industries — 9:35-9:55

  - The legal treatment of geothermal resources in Oregon; Kyle Huber, Attorney at Law — 9:55-10:05

  - Questions & Answers

* Coffee Break — 10:15-10:25

* Geothermal Direct Utilization & Economics:

  - Principles and practices for space conditioning, industrial processing, agriculture and aquaculture, and district heating; Paul Lienau, O.I.T. Geoheat Center — 10:25-10:50

  - Overview of direct utilization economics for geothermal development and operations; Charles Higbee, O.I.T. Geoheat Center — 10:50-11:10

  - Questions & Answers

* Technical & Funding Assistance and Incentives:

- The O.I.T. Geoheat Center Technical Assistance Program; Paul Lienau, O.I.T. Geoheat Center — 11:20-11:35

- Funding assistance and incentives; Eliot Allen, Eliot Allen & Associates, Inc. — 11:35-11:45

- Questions & Answers

III. LUNCHEON

* Keynote address: Lynn Frank, Director, Oregon Department of Energy — 12:05-12:55

IV. AFTERNOON SESSION: Moderator, Richard Bowen, Consulting Geologist

* Geothermal Progress in the Pacific Northwest:

- Washington; Dr. Gordon Bloomquist, Washington State Energy Office — 1:05-1:20

- Idaho; Alex Sifford, Idaho Energy Office — 1:20-1:35

- Klamath Falls; Jim Watson, City of Klamath Falls, Oregon — 1:35-1:55

- Lakeview & Mt. Hood/Portland; Carl Petterson, Northwest Geothermal Corp. — 1:55-2:15

- Oakridge; Dave Waffle, City of Oakridge, Oregon — 2:15-2:35

- Questions & Answers

* Coffee Break — 2:45-2:55

* Geothermal Environmental & Land-Use Issues:

- Overview of environmental issues; Dr. Peter Paquet, Oregon Department of Energy — 2:55-3:15

- Status of Oregon's environmental quality programs; Kent Ashbaker, Oregon Department of Environmental Quality — 3:15-3:30

- Land-use planning issues affecting geothermal; Eliot Allen and Steve Pfeiffer, Eliot Allen & Associates, Inc.

- Questions & Answers

* State & Federal Geothermal Programs:

- Kent Mathiot, Oregon Department of Water Resources	3:35-3:45
- Tom Notos, Oregon Department of Economic Development	3:45-3:55
- Roald Bendixen, U.S. Department of Energy	3:55-4:05
- Frank Edwards, U.S. Bureau of Land Management	4:05-4:15
- Merle Hofferber, U.S. Forest Service	4:15-4:25
- Questions & Answers	
* Adjourn	4:45

V. NO-HOST CASH BAR 4:45-5:30

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Oregon Geothermal Planning Conference
Bend, Oregon
October 2, 1980

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October 2, 1980

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July 30, 1980

THE OREGON GEOTHERMAL PLANNING PROGRAM

Oregon's geothermal resources represent a large portion of the nation's total geothermal potential. The State's resources are substantial in size, widespread in location, and presently in various stages of discovery and utilization. The exploration for, and development of, geothermal is presently dependent upon a mixture of engineering, economic, environmental, and legal factors.

In response to the State's significant geothermal energy potential, and the emerging impediments and incentives for its development, the State of Oregon has begun a planning program intended to accelerate the environmentally prudent utilization of geothermal, while conserving the resource's long-term productivity. The program, which is based upon preliminary work performed by the Oregon Institute of Technology's Geo-Heat Center, will be managed by the Oregon Department of Energy, with the assistance of the Departments of Economic Development, Geology & Mineral Industries, and Water Resources. Funding support for the program is being provided by the U.S. Department of Energy.

The first six-month phase of the program, beginning in July 1980, will include the following five primary tasks:

1) Coordination of state and local agency projects and information, in order to keep geothermal personnel abreast of the rapidly expanding resource literature, resource discoveries, technological advances, and each agency's projects.

2) Analysis of resource commercialization impediments and recommendations of incentives for accelerating resource utilization.

3) Compilation and dissemination of Oregon geothermal information, in order to create public and potential user awareness, and to publicize technical assistance programs and financial incentives.

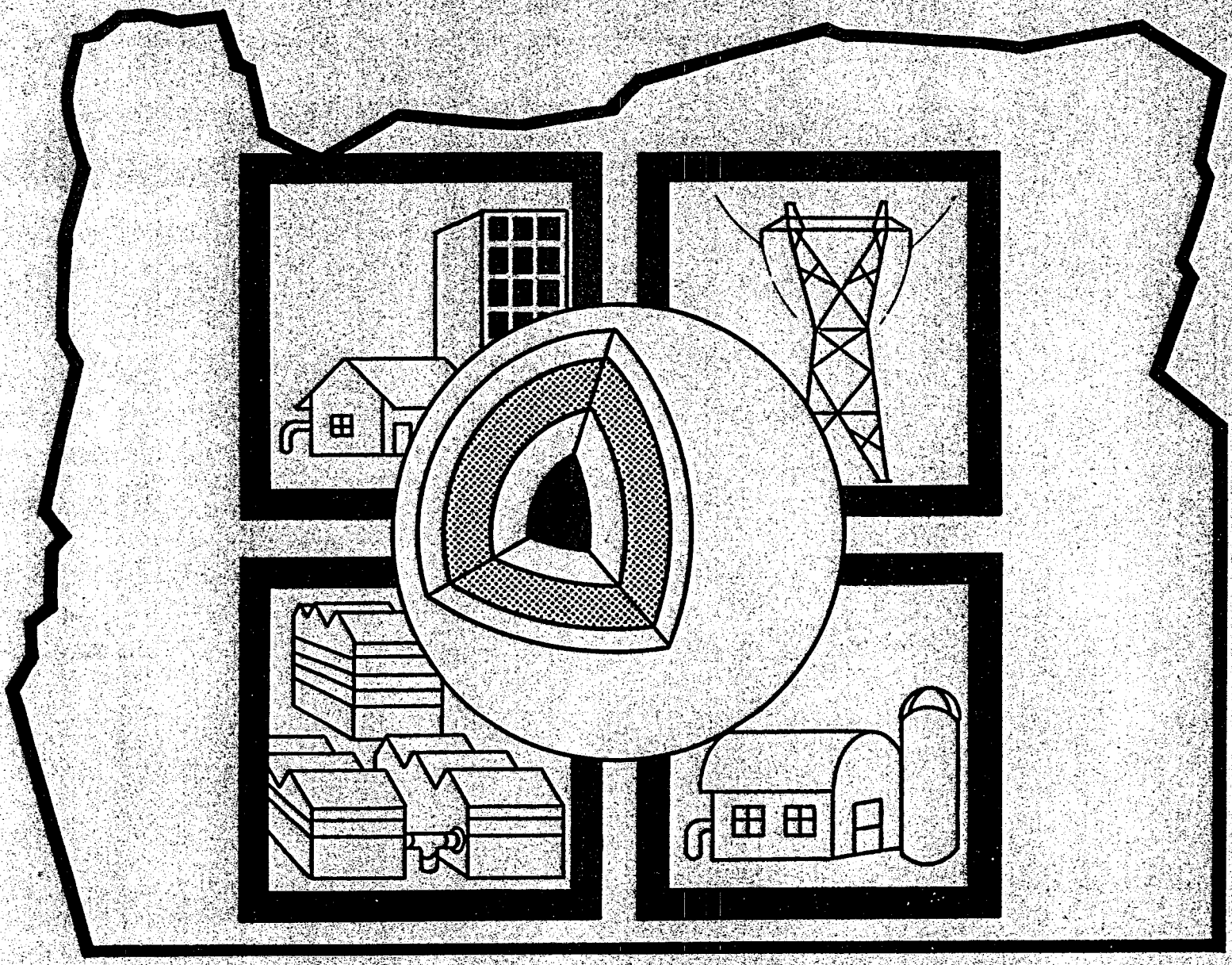
4) Resource planning assistance for local governments in order to create local expertise and action; including a statewide workshop for local officials, and the formulation of two specific community resource development plans.

5) Formulation and implementation of various statewide incentives; emphasis will be given to the recommendations of the Oregon Alternate Energy Development Commission and its Geothermal Task Force.

More information on the geothermal planning program may be obtained from the Oregon Department of Energy (Salem, 503-378-4040), or from ODOE's geothermal planning consultant, Eliot Allen & Associates, Inc. (Salem, 503-371-4561).

DP:bc

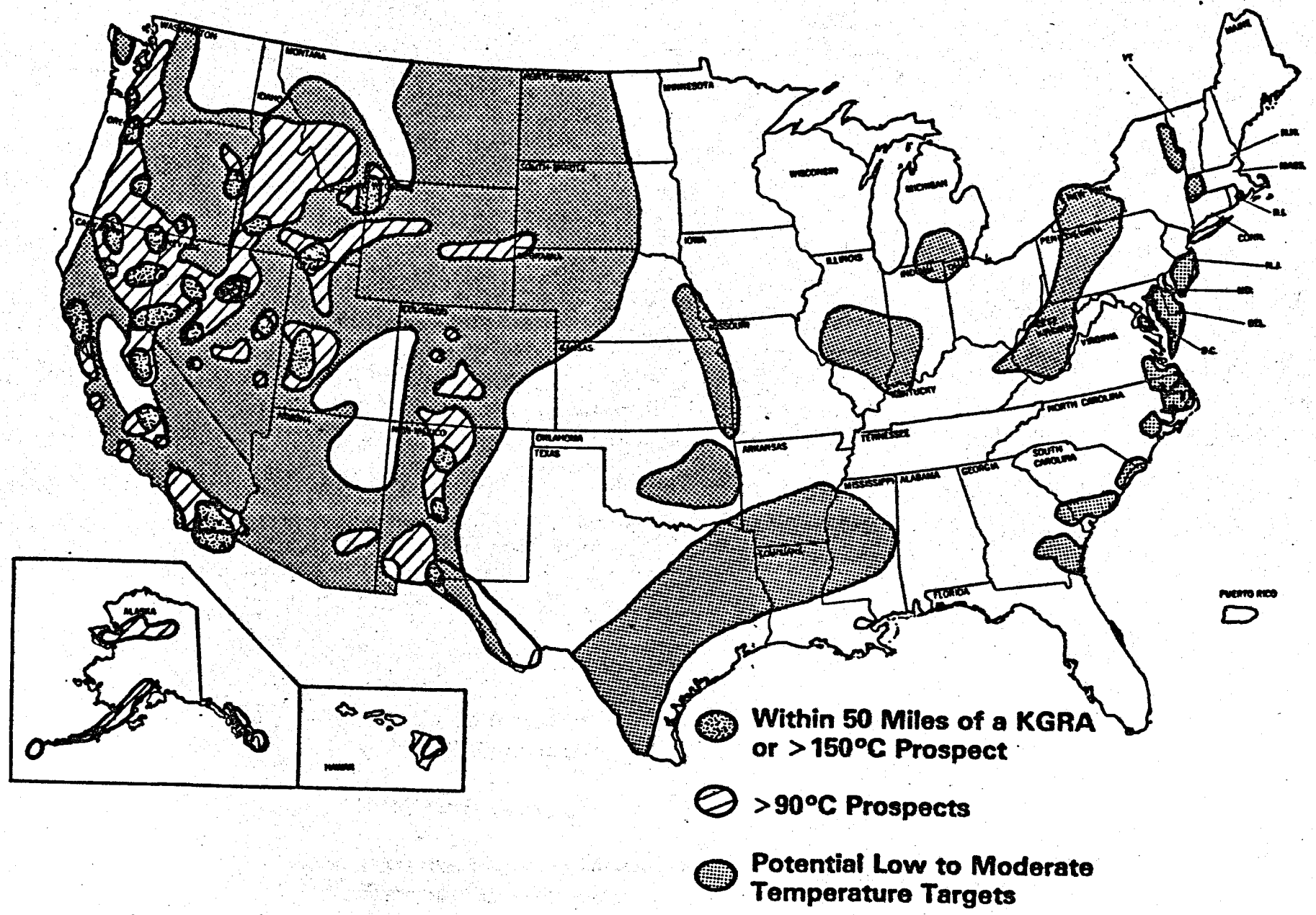
OREGON



GEOTHERMAL

INTRODUCTION

Known and Potential Hydrothermal Resources



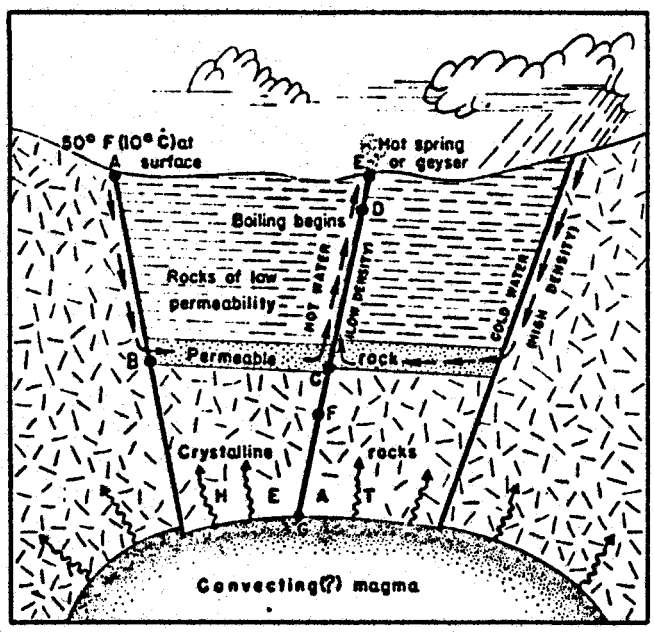


FIGURE 2. Schematic model of a hydrothermal convection system driven by an underlying young igneous intrusion (modified from White, 1968).

Fault-controlled systems

Most hydrothermal convection systems are not located in areas where young igneous intrusions have been identified. Instead, these geothermal systems derive their heat from large volumes of rock by deep circulation of water along permeable zones, which may be either stratigraphic beds or networks of faults and fractures (Figure 3). The temperature attained by the water is primarily dependent upon the magnitude of the regional heat flow and the depth to which the water circulates. Recharge to the downward-circulating limb of the hydrothermal convection system may occur over both mountain areas and adjacent valleys. The types of fractures and faults could differ from those shown in the generalized model of Figure 3; the only requirement is that the faults or fractures be permeable enough to transmit the rising hot water.

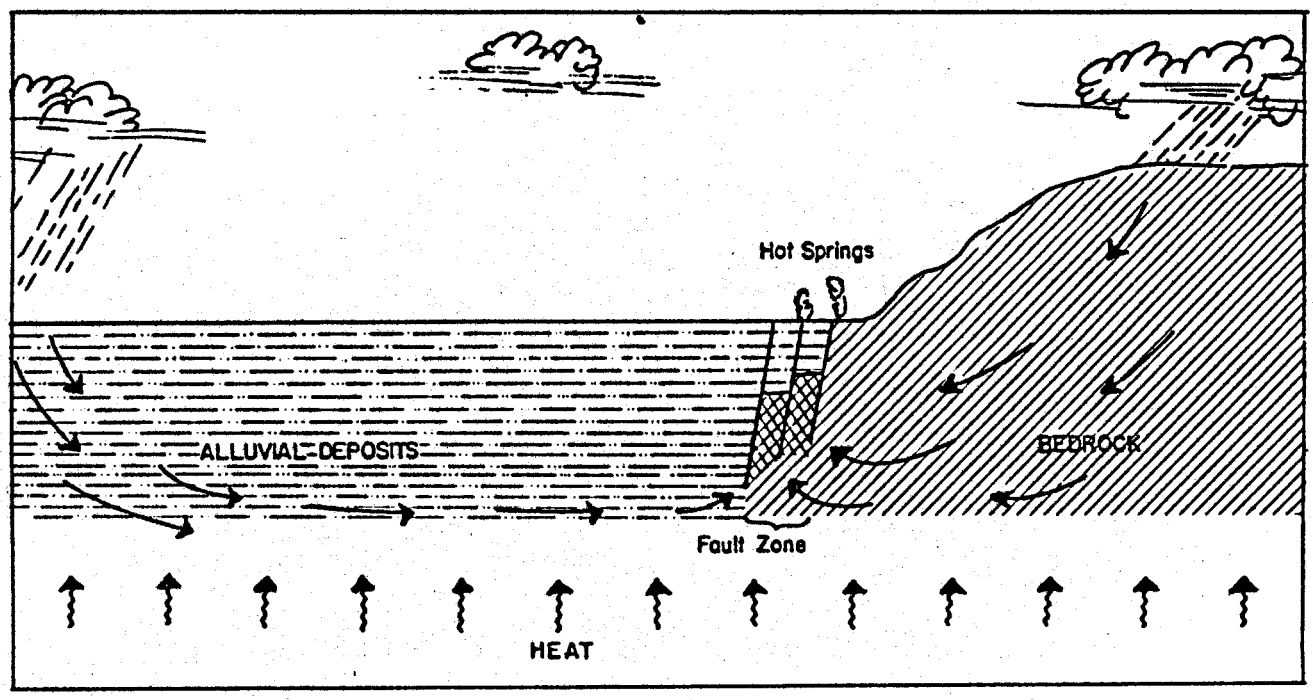
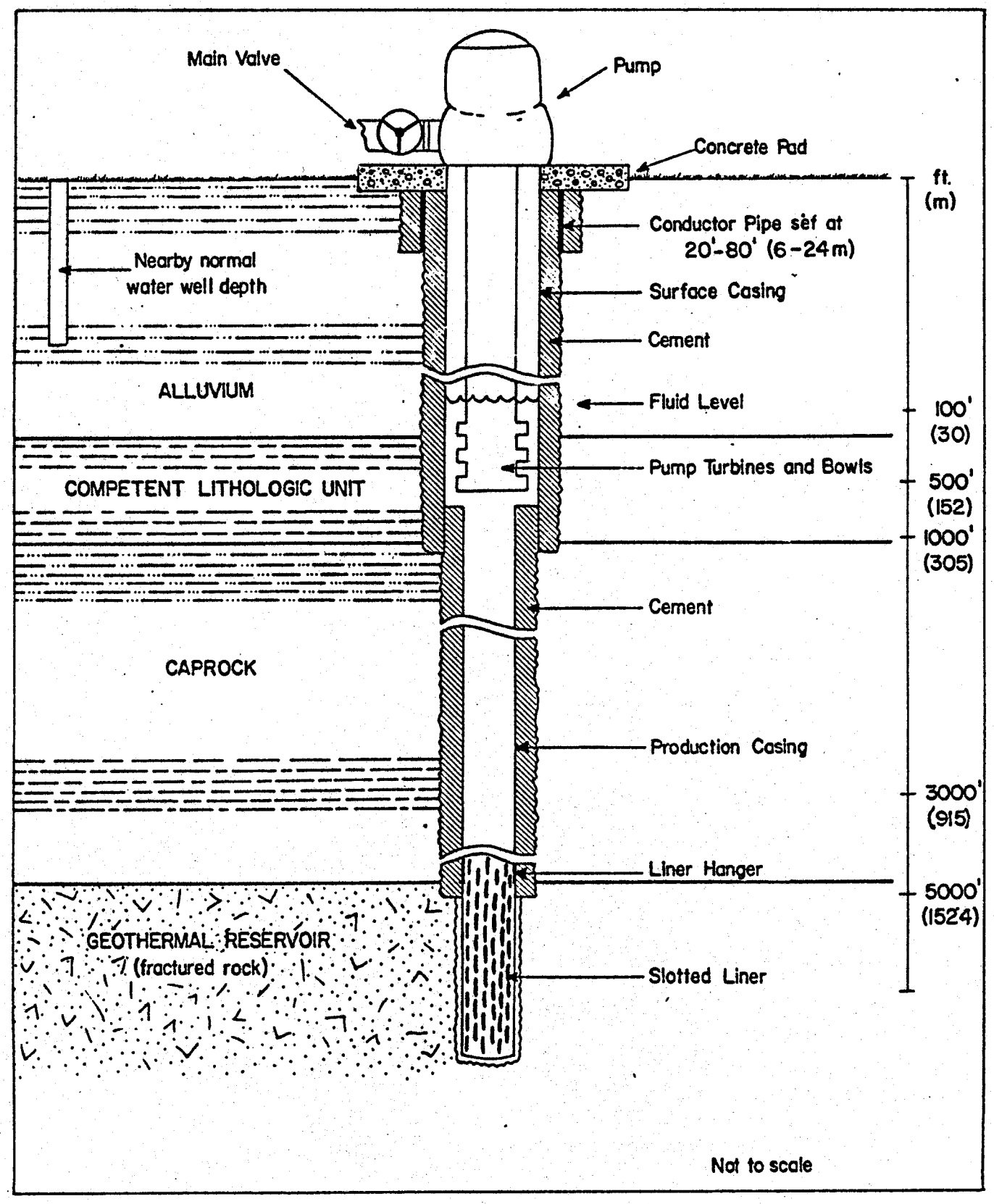


FIGURE 3. Schematic model of a hydrothermal convection system related to deep circulation of meteoric water without the influence of young igneous intrusions.

TABLE I

Summary of costs, time frames and area covered with various geothermal exploration methods

Method	Time	Expense	Area
Consulting geologist	< month	$200-$400/day	Regional/detailed
Airphoto interpretation	< month	$5/mi^2 ($2/km^2)	Regional/detailed
Water analyses	month	$100-$200/sample	Regional/detailed
Surface geochemistry	month	$30/sample	Detailed
Volatile geochemistry	month	$20/sample	Detailed
Temperature gradient/heat flow boreholes	> month	$10-$100/ft ($30-$300/m)	Regional/detailed
Electromagnetic methods	month	$200-$1500/line mi ($125-$930/line km)	Detailed
Resistivity	month	$200-$1500/line mi ($125-$930/line km)	Detailed
Magnetics - airborne	< month	$25/line mi ($15/km)	Regional
- ground	< month	$200/line mi ($125/km)	Detailed
Seismic - refraction	< month	$5000/line mi ($3000/km)	Detailed
- reflection	< month	$5000-$10,000/line mi ($3000-$6000/km)	Detailed
- microearthquakes	3-6 months	$1200/day	Regional/detailed
Gravity	month	$30-$70 station	Regional/detailed
Magnetotelluric	month	$1200-$2000/line mi ($750-$1250/km)	
Geophysical logging	< week	$2000-$20,000/hole	Detailed



Typical design for a low- to moderate-temperature geothermal well.

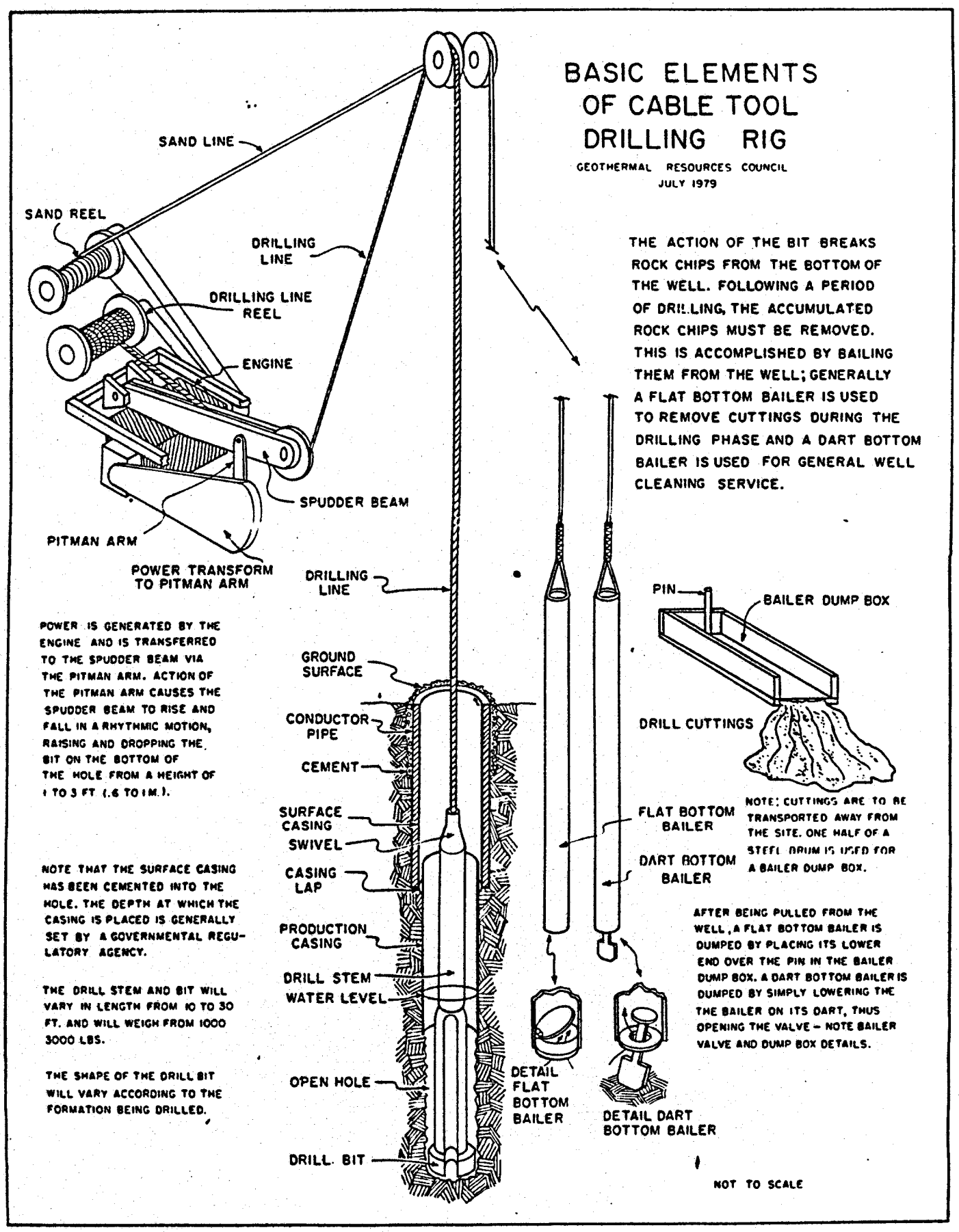

BASIC ELEMENTS OF CABLE TOOL DRILLING RIG
GEOTHERMAL RESOURCES COUNCIL
JULY 1979
SAND LINE
SAND REEL
DRILLING LINE
DRILLING LINE REEL
ENGINE
SPUDDER BEAM
PITMAN ARM
POWER TRANSFORM TO PITMAN ARM
POWER IS GENERATED BY THE ENGINE AND IS TRANSFERRED TO THE SPUDDER BEAM VIA THE PITMAN ARM. ACTION OF THE PITMAN ARM CAUSES THE SPUDDER BEAM TO RISE AND FALL IN A RHYTHMIC MOTION, RAISING AND DROPPING THE BIT ON THE BOTTOM OF THE HOLE FROM A HEIGHT OF 1 TO 3 FT (.6 TO 1 M.).
NOTE THAT THE SURFACE CASING HAS BEEN CEMENTED INTO THE HOLE. THE DEPTH AT WHICH THE CASING IS PLACED IS GENERALLY SET BY A GOVERNMENTAL REGULATORY AGENCY.
THE DRILL STEM AND BIT WILL VARY IN LENGTH FROM 10 TO 30 FT. AND WILL WEIGH FROM 1000 3000 LBS.
THE SHAPE OF THE DRILL BIT WILL VARY ACCORDING TO THE FORMATION BEING DRILLED.
DRILLING LINE
GROUND SURFACE
CONDUCTOR PIPE
CEMENT
SURFACE CASING
SWIVEL
CASING LAP
PRODUCTION CASING
DRILL STEM
WATER LEVEL
OPEN HOLE
DRILL BIT
THE ACTION OF THE BIT BREAKS ROCK CHIPS FROM THE BOTTOM OF THE WELL. FOLLOWING A PERIOD OF DRILLING, THE ACCUMULATED ROCK CHIPS MUST BE REMOVED. THIS IS ACCOMPLISHED BY BAILING THEM FROM THE WELL; GENERALLY A FLAT BOTTOM BAILER IS USED TO REMOVE CUTTINGS DURING THE DRILLING PHASE AND A DART BOTTOM BAILER IS USED FOR GENERAL WELL CLEANING SERVICE.
PIN
BAILER DUMP BOX
DRILL CUTTINGS
NOTE: CUTTINGS ARE TO BE TRANSPORTED AWAY FROM THE SITE. ONE HALF OF A STEEL DRUM IS USED FOR A BAILER DUMP BOX.
FLAT BOTTOM BAILER
DART BOTTOM BAILER
AFTER BEING PULLED FROM THE WELL, A FLAT BOTTOM BAILER IS DUMPED BY PLACING ITS LOWER END OVER THE PIN IN THE BAILER DUMP BOX. A DART BOTTOM BAILER IS DUMPED BY SIMPLY LOWERING THE THE BAILER ON ITS DART, THUS OPENING THE VALVE – NOTE BAILER VALVE AND DUMP BOX DETAILS.
DETAIL FLAT BOTTOM BAILER
DETAIL DART BOTTOM BAILER
NOT TO SCALE

FIGURE 1

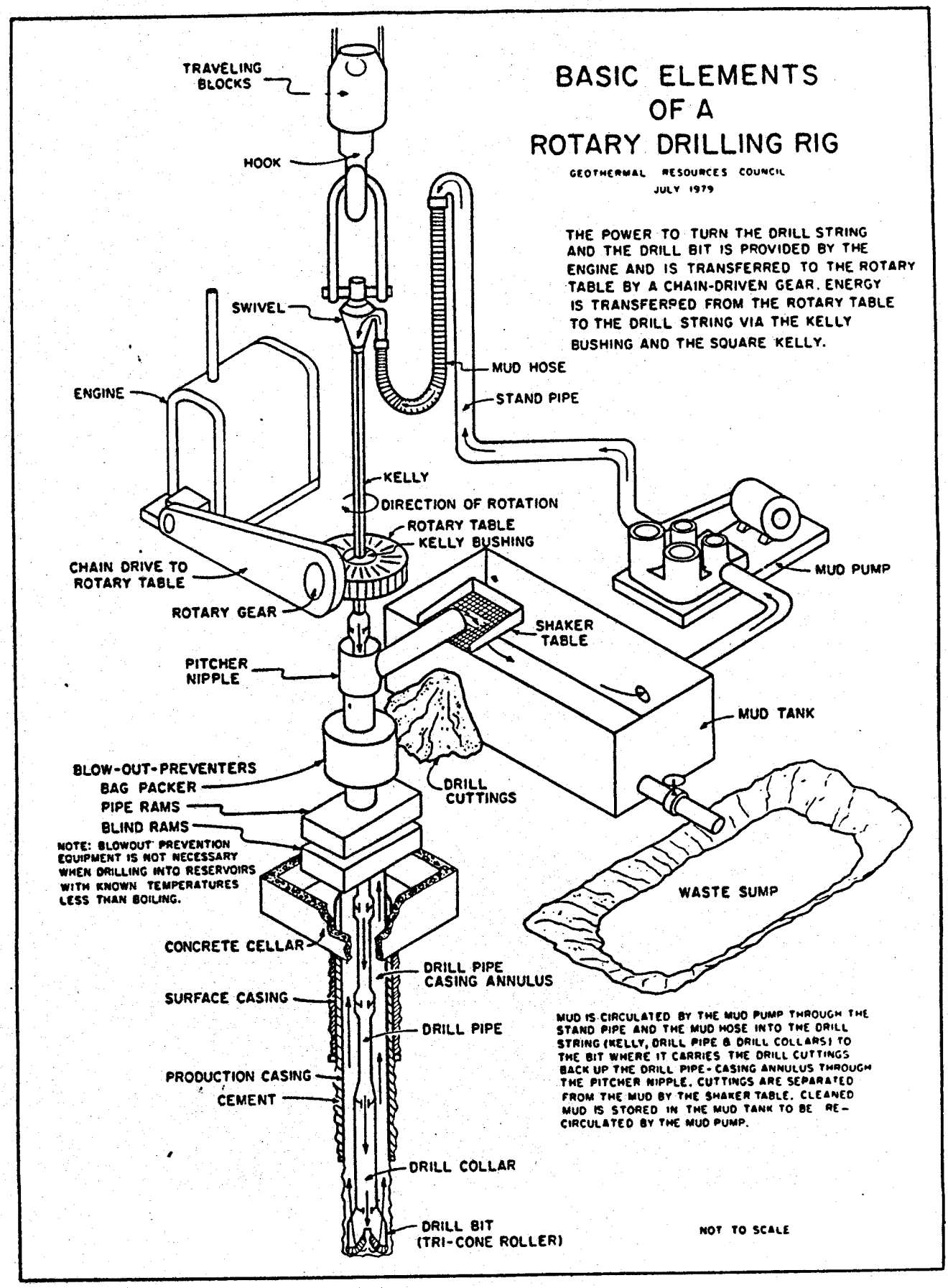
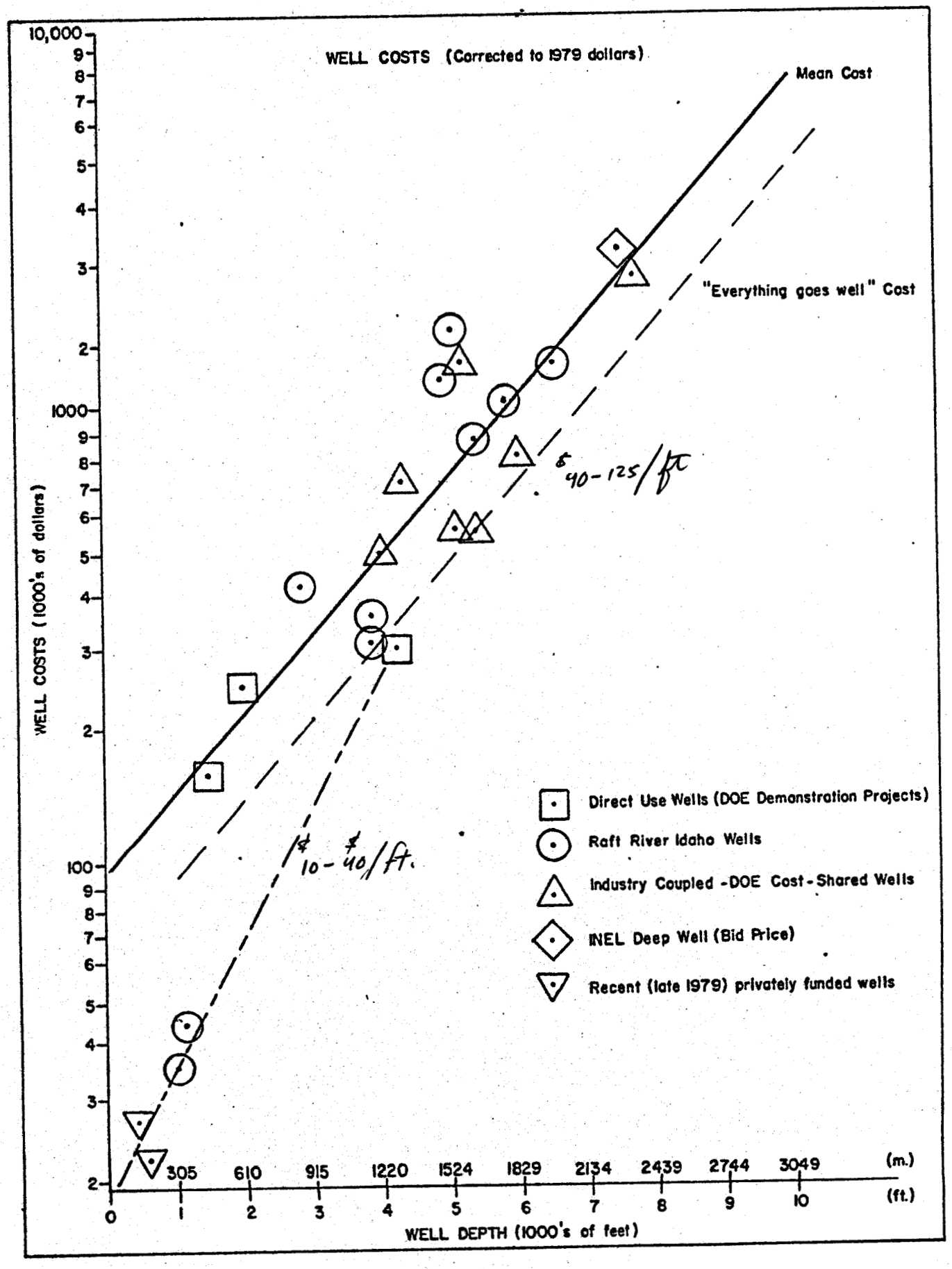

BASIC ELEMENTS OF A ROTARY DRILLING RIG
GEOTHERMAL RESOURCES COUNCIL
JULY 1979
THE POWER TO TURN THE DRILL STRING AND THE DRILL BIT IS PROVIDED BY THE ENGINE AND IS TRANSFERRED TO THE ROTARY TABLE BY A CHAIN-DRIVEN GEAR. ENERGY IS TRANSFERRED FROM THE ROTARY TABLE TO THE DRILL STRING VIA THE KELLY BUSHING AND THE SQUARE KELLY.
TRAVELING BLOCKS
HOOK
SWIVEL
ENGINE
MUD HOSE
STAND PIPE
KELLY
DIRECTION OF ROTATION
ROTARY TABLE
KELLY BUSHING
CHAIN DRIVE TO ROTARY TABLE
ROTARY GEAR
MUD PUMP
SHAKER TABLE
PITCHER NIPPLE
MUD TANK
BLOW-OUT-PREVENTERS
BAG PACKER
PIPE RAMS
BLIND RAMS
DRILL CUTTINGS
NOTE: BLOWOUT PREVENTION EQUIPMENT IS NOT NECESSARY WHEN DRILLING INTO RESERVOIRS WITH KNOWN TEMPERATURES LESS THAN BOILING.
WASTE SUMP
CONCRETE CELLAR
DRILL PIPE CASING ANNULUS
SURFACE CASING
DRILL PIPE
MUD IS CIRCULATED BY THE MUD PUMP THROUGH THE STAND PIPE AND THE MUD HOSE INTO THE DRILL STRING (KELLY, DRILL PIPE & DRILL COLLARS) TO THE BIT WHERE IT CARRIES THE DRILL CUTTINGS BACK UP THE DRILL PIPE-CASING ANNULUS THROUGH THE PITCHER NIPPLE. CUTTINGS ARE SEPARATED FROM THE MUD BY THE SHAKER TABLE. CLEANED MUD IS STORED IN THE MUD TANK TO BE RE-CIRCULATED BY THE MUD PUMP.
PRODUCTION CASING
CEMENT
DRILL COLLAR
DRILL BIT (TRI-CONE ROLLER)
NOT TO SCALE

FIGURE 2



Typical drilling costs for geothermal wells (corrected to 1979 dollars).

Geothermal exploration in Oregon, 1979

by Joseph F. Riccio, Geothermal Specialist, and Dennis L. Olmstead, Geologist, Oregon Department of Geology and Mineral Industries

ABSTRACT

Government agencies and university researchers continued their geothermal research effort in Oregon during 1979. The Oregon Department of Geology and Mineral Industries placed emphasis on the evaluation of Oregon's low-temperature resource areas and the geothermal potential of the central Cascades.

Industrial exploration decreased, and no major discoveries were reported. The major effort by industry was the drilling of the 10,050-ft well at Ontario, Malheur County, by Ore-Ida Foods, Inc. During the year, the Department issued permits for 201 temperature-gradient holes less than 500 ft deep and for 35 holes more than 500 ft deep. Ninety shallow and 29 deep holes were actually drilled.

INDUSTRY ACTIVITY

Oregon's deepest geothermal test well (depth 10,050 ft) to date was drilled in Ontario, Malheur County (Figure 1), at a cost of $4.8 million, by Ore-Ida Foods, Inc., in conjunction with the U.S. Department of Energy (USDOE). The well was spudded on August 19, 1979, by Montgomery Drilling Company of Bakersfield, California. Temperatures approximating 400°F were reported from this hole; however, the amount of geothermal fluid recovered from an initial drill-stem test was not sufficient in volume to warrant completion of the well. The hole is currently shut-in, pending further geologic and engineering analyses and additional testing.

The Eugene Water and Electric Board (EWEB) initiated and completed the drilling of six temperature-gradient holes in the central Cascades (Figure 2). Maximum depth of exploration was 1,960 ft. This undertaking was in conjunction with Southland Royalty Company and Sunoco Energy Development Company. Funding, in part, was by USDOE.

The remainder of the exploration effort by industry (Tables 1 and 2) was restricted to the drilling of temperature-gradient holes to depths ranging from 500 to 2,000 ft. Prior to September 1, 1979, prospect wells included only those drilled to 500 ft or less. According to the present Oregon law relating to geothermal exploration and development, however, the term "prospect well" includes any geophysical test well, seismic shot hole, mineral exploration drilling, core drilling, or temperature-gradient test well that is less than 2,000 ft in depth and is drilled during the prospecting for geothermal resources. This change in the law influenced the 1979 trends shown on the graphs in Figures 3 and 4 and the data presented in the abstract.

Old Maid Flat 1, the geothermal exploratory test well drilled on the flanks of Mt. Hood by Northwest Geothermal Corporation, is still shut-in. Plans are currently being formulated to obtain fluid samples for geochemical analyses from several of the potentially producing aquifers. If these tests prove successful, flow testing of the well may be considered for late summer of 1980.

Leasing

Acquisition of geothermal leases continued in Oregon during 1979. The total Federal acreage leased

Figure 1. Ore-Ida Foods, Inc., Well 1, Ontario, Malheur County, Oregon.

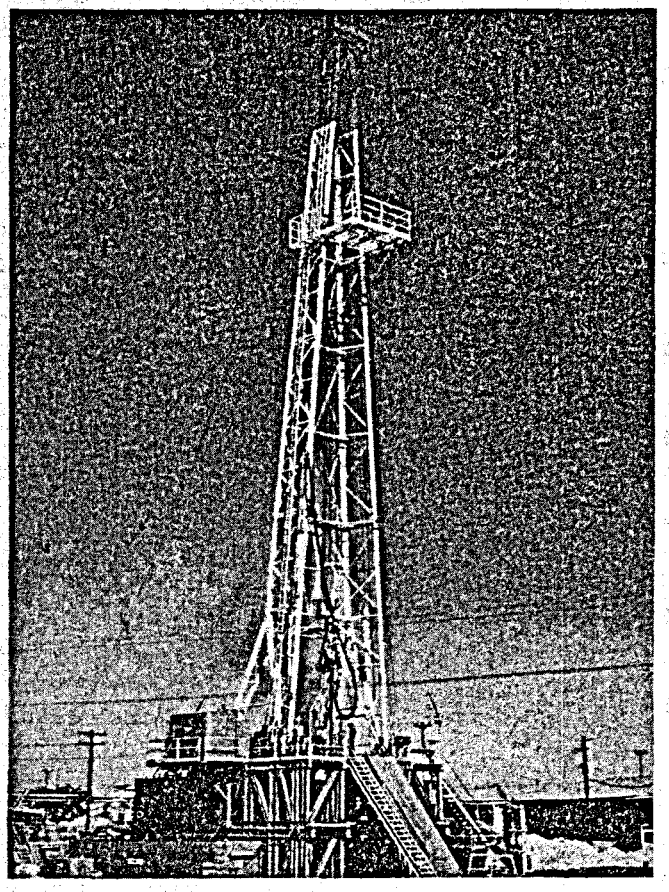


Table 1. *Geothermal permits and drilling activity in Oregon, 1979*

Permit no.	Operator	Well name	Location	Total depth (ft)	Status
37	Anadarko Production	Alvord Valley Hole A-7	SW¼ sec. 18 T. 33 S., R. 36 E. Harney County	–	Location, proposed depth 2,000 ft.
38	Anadarko Production	Alvord Valley Hole A-8	SE¼ sec. 14 T. 33 S., R. 35 E. Harney County	–	Location, proposed depth 2,000 ft.
39	Anadarko Production	Alvord Valley Hole A-26	NE¼ sec. 29 T. 34 S., R. 34 E. Harney County	–	Location, proposed depth 2,000 ft.
40	Anadarko Production	Alvord Valley Hole A-31	SW¼ sec. 34 T. 34 S., R. 34 E. Harney County	–	Location, proposed depth 2,000 ft.
41	Anadarko Production	Alvord Valley Hole A-34	NE¼ sec. 8 T. 35 S., R. 34 E. Harney County	–	Location, proposed depth 2,000 ft.
42	Anadarko Production	Alvord Valley Hole B-56	SE¼ sec. 10 T. 37 S., R. 33 E. Harney County	–	Location, proposed depth 2,000 ft.
43	Anadarko Production	Alvord Valley Hole B-61	SW¼ sec. 13 T. 37 S., R. 33 E. Harney County	–	Location, proposed depth 2,000 ft.
44	Anadarko Production	Alvord Valley Hole B-64	NW¼ sec. 22 T. 37 S., R. 33 E. Harney County	–	Location, proposed depth 2,000 ft.
45	U.S. Geological Survey	Newberry Crater 2	SW¼ sec. 31 T. 21 S., R. 13 E. Deschutes County	2,076	Drilling suspended October 1979; will deepen to 3,000 ft in 1980.
46	Ore-Ida Foods, Inc.	Well 1	NE¼ sec. 3 T. 18 S., R. 47 E. Malheur County	10,050	Well suspended for monitoring.
47	Ore-Ida Foods, Inc.	Well 2	SE¼ sec. 3 T. 18 S., R. 47 E. Malheur County	–	Drilling postponed pending evaluation of Well No. 1.
48	Chevron Resources	Neals-Bully Creek 79-2	SE¼ sec. 32 T. 17 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
49	Chevron Resources	Neals-Bully Creek 79-4	SW¼ sec. 33 T. 17 S., R. 43 E. Malheur County	2,010	Temperature-gradient well.
50	Chevron Resources	Neals-Bully Creek 79-5	NE¼ sec. 4 T. 18 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
51	Chevron Resources	Neals-Bully Creek 79-6	SE¼ sec. 8 T. 18 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
52	Chevron Resources	Neals-Bully Creek 79-7	NW¼ sec. 3 T. 18 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
53	Chevron Resources	Neals-Bully Creek 79-8	NW¼ sec. 28 T. 17 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.
54	Chevron Resources	Neals-Bully Creek 79-10	NE¼ sec. 15 T. 18 S., R. 43 E. Malheur County	1,868	Temperature-gradient well.
55	Chevron Resources	Neals-Bully Creek 79-11	NW¼ sec. 9 T. 18 S., R. 43 E. Malheur County	–	Location, proposed depth 2,000 ft.

Table 1. *Geothermal permits and drilling activity in Oregon, 1979 (continued)*

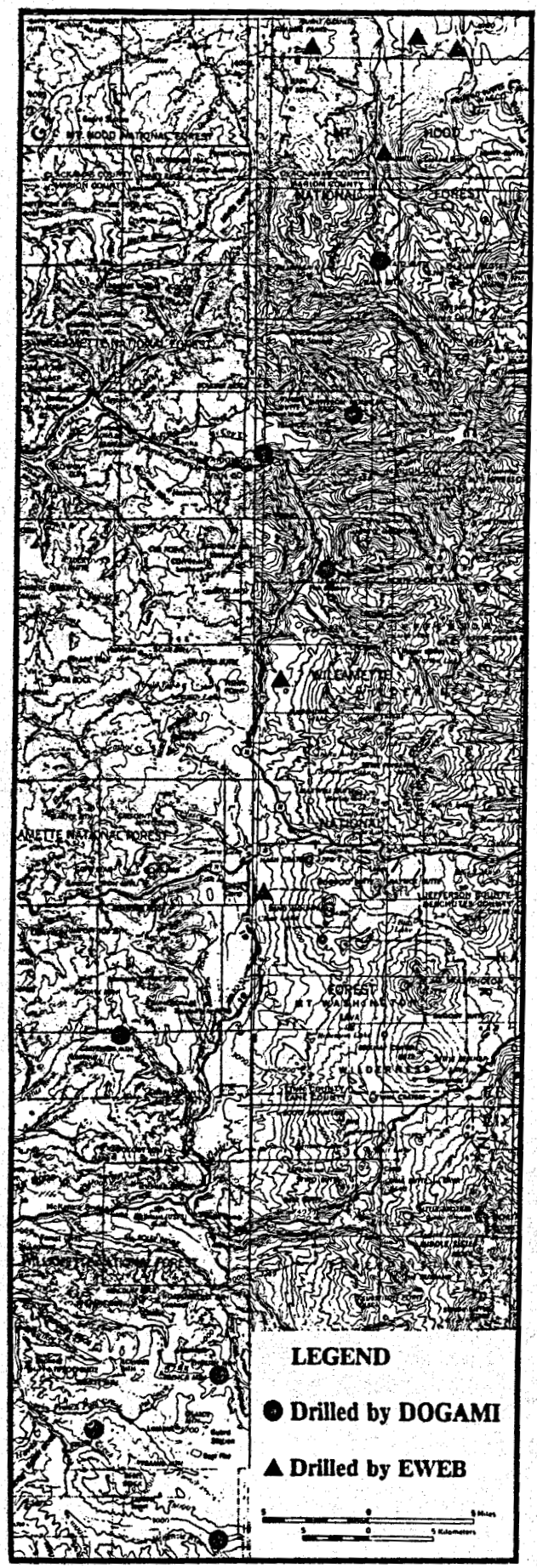
Permit no.	Operator	Well name	Location	Total depth (ft)	Status
56	Union Oil Company	Brooks Scanlon 1	NW¼ sec. 2 T. 24 S., R. 11 E. Klamath County	705	Abandoned, temperature-gradient well.
57	Union Oil Company	Brooks Scanlon 2	SW¼ sec. 5 T. 23 S., R. 11 E. Klamath County	550	Abandoned, temperature-gradient well.
58	Union Oil Company	Brooks Scanlon 3	SW¼ sec. 29 T. 23 S., R. 11 E. Klamath County	–	Will not be drilled.
59	Union Oil Company	Brooks Scanlon 4	NE¼ sec. 15 T. 26 S., R. 12 E. Lake County	–	Will not be drilled.
60	Union Oil Company	Brooks Scanlon 5	SW¼ sec. 36 T. 26 S., R. 12 E. Lake County	975	Abandoned, temperature-gradient well.
61	Union Oil Company	Brooks Scanlon 6	SW¼ sec. 32 T. 25 S., R. 12 E. Lake County	1,010	Abandoned, temperature-gradient well.
62	Union Oil Company	Brooks Scanlon 7	NE¼ sec. 12 T. 17 S., R. 10 E. Deschutes County	–	Will not be drilled.
63	Union Oil Company	Brooks Scanlon 8	SE¼ sec. 30 T. 17 S., R. 11 E. Deschutes County	840	Abandoned, temperature-gradient well.
64	Union Oil Company	Brooks Scanlon 9	NE¼ sec. 27 T. 16 S., R. 10 E. Deschutes County	860	Abandoned, temperature-gradient well.
65	Northwest Natural Gas	Jct. Highways 26 and 35	NE¼ sec. 30 T. 3 S., R. 9 E. Clackamas County	965	Suspended, temperature-gradient well.
66	Northwest Natural Gas	Zigzag 1	NW¼ sec. 14 T. 3 S., R. 8 E. Clackamas County	940	Suspended, temperature-gradient well.
67	Northwest Natural Gas	Still Creek 1	NW¼ sec. 35 T. 3 S., R. 8 E. Clackamas County	–	Location, temperature-gradient well.
68	Eugene Water and Electric Board	Road 075	NE¼ sec. 4 T. 13 S., R. 7 E. Linn County	–	Location, temperature-gradient well.
69	Eugene Water and Electric Board	Sisi Creek	SW¼ sec. 6 T. 8 S., R. 8 E. Clackamas County	1,505	Suspended, temperature-gradient well.
70	U.S. Geological Survey	Pucci Chairlift	SE¼ sec. 7 T. 3 S., R. 9 E. Clackamas County	2,000	To be deepened to approximately 3,000 ft in 1980.
71	Francana Resources, Inc.	Glass Buttes 1	NW¼ sec. 31 T. 22 S., R. 23 E. Lake County	2,000	Abandoned, temperature-gradient well.
72	Francana Resources, Inc.	Glass Buttes 2	SW¼ sec. 17 T. 23 S., R. 23 E. Lake County	–	Location, proposed depth 2,000 ft.
73	Eugene Water and Electric Board	Fish Lake Creek	SE¼ sec. 32 T. 13 S., R. 7 E. Clackamas County	1,837	Suspended, temperature-gradient well.
74	Eugene Water and Electric Board	Twin Meadows	SE¼ sec. 9 T. 12 S., R. 7 E. Clackamas County	1,960	Suspended, temperature-gradient well.

Table 1. *Geothermal permits and drilling activity in Oregon, 1979 (continued)*

Permit no.	Operator	Well name	Location	Total depth (ft)	Status
75	Eugene Water and Electric Board	Poop Creek	SE¼ sec. 5 T. 7 S., R. 8 E. Clackamas County	870	Suspended, temperature-gradient well.
76	Eugene Water and Electric Board	Cinder Cone	NE¼ sec. 10 T. 7 S., R. 8 E. Clackamas County	1,160	Suspended, temperature-gradient well.
77	Eugene Water and Electric Board	Tarzan Spring	SE¼ sec. 4 T. 7 S., R. 7 E. Clackamas County	710	Suspended, temperature-gradient well.
78	Eugene Water and Electric Board	Pinhead	NE¼ sec. 35 T. 7 S., R. 8 E. Clackamas County	–	Location, temperature-gradient well.
79	Eugene Water and Electric Board	Crescent Creek	SE¼ sec. 13 T. 13 S., R. 6 E. Clackamas County	–	Location, temperature-gradient well.
80	Chevron Resources	Jordan 55	NW¼ sec. 9 T. 18 S., R. 43 E. Malheur County	–	Drilling at 2,600 ft, January 1980.

Table 2. *Geothermal prospect permits and drilling activity in Oregon, 1979*

Permit no.	Operator	Issue date	Locations	Comments and status
38	Phillips Petroleum Company	May 1978	Brothers Fault Zone, Lake and Harney Counties	Drilled 17 more 500-ft gradient holes in 1979, continuing the 1978 program.
47	Northwest Natural Gas	Nov. 1978	Mt. Hood Clackamas County	Summit Meadows well drilled to 1,115 ft. Lost Creek well drilled to 431 ft. Clear Fork well drilled to 495 ft.
48	Chevron Resources	April 1979	Bully Creek Malheur County	Drilled two 500-ft and two 2,000-ft gradient holes.
49	Technology International	April 1979	Vale Malheur County	Location, temperature-gradient well.
50	Phillips Petroleum Company	July 1979	Lakeview Harney County	Drilled 24 500-ft gradient holes in 1979.
51	Francana Resources	July 1979	Glass Buttes Lake County	Drilled one hole to 2,000 ft, suspended to monitor temperature.
52	Chevron Resources	July 1979	South Crump Lake Lake County	Drilled 14 500-ft gradient holes in 1979.
53	Chevron Resources	July 1979	Bully Creek Malheur County	Drilled four 500-ft gradient holes in 1979.
54	Oregon Department of Geology and Mineral Industries	Aug. 1979	Cascades Clackamas County	Drilled eight 500-ft gradient holes in 1979.
55	U.S. Geological Survey	Aug. 1979	Mt. Hood Clackamas County	Drilled two wells in 1979; deepest 1,002 ft.
56	Republic Geothermal	Aug. 1979	Vale Malheur County	Drilled four wells in 1979; three to depth of 500 ft and one to 1,500 ft.
57	Anadarko Production Company	Sept. 1979	Alvord Valley Harney County	Drilled six 500-ft and one 900-ft gradient holes in 1979.
58	Union Oil Company	Oct. 1979	Alvord Valley Harney County	Location, temperature-gradient well.
59	Eugene Water and Electric Board	Sept. 1979	Breitenbush Linn County	Location, temperature-gradient well.
60	Oregon Department of Geology and Mineral Industries	Nov. 1979	Lakeview Lake County	Drilled eight 500-ft gradient holes in 1979.
61	Oregon Department of Geology and Mineral Industries	Nov. 1979	La Grande Union County	Drilled two 500-ft gradient holes in 1979.



was a little greater than in 1978. Totals of Federal and State leases in Oregon are shown in Table 3. The acreage noted for the private leases is an estimate because confirmation is difficult.

Table 3. *Geothermal leases in Oregon, 1979*

Type of leases	Number	Acres
Federal		
Noncompetitive	113 USBLM*	165,678
	23 USFS**	38,872
Competitive	21 USBLM*	43,082
	4 USFS**	5,818
Applications pending	123 USBLM*	
	368 USFS**	
Total		253,450
State		
Leases active in 1979		8,934
Applications pending		3
Private		
Leases active in 1979 (est.)		160,000

* U.S. Bureau of Land Management
** U.S. Forest Service

There were no U.S. Bureau of Land Management (USBLM) lease sales in calendar year 1979. However, four energy companies—Anadarko Production Company, Hunt Oil Company, Intercontinental Energy Corporation, and Union Oil Company—were successful bidders on the sale held January 8, 1980, on six parcels of Federal land in Oregon in the following KGRA's: Alvord, Breitenbush, Crump, and Klamath Falls (Table 4). Sixty-two parcels were offered by the Federal government. Forty-nine parcels received no bids, and seven others were withdrawn. The withdrawn parcels and those that did not receive bids will be re-offered as part of a geothermal lease sale planned for April 29, 1980.

After the April 29 sale, the USBLM will probably recommend to the U.S. Geological Survey (USGS) that those parcels which received no bids at this and several previous sales be removed from KGRA classification.

A sale of parcels in Oregon in the Belknap-Foley Hot Springs, McCredie, and Newberry Caldera KGRA's is tentatively planned for October 23, 1980, contingent upon the forwarding of leasing recommendations by the USGS.

← *Figure 2. Location of temperature-gradient holes drilled by Eugene Water and Electric Board and Oregon Department of Geology and Mineral Industries, 1979.*

Table 4. *U.S. Bureau of Land Management KGRA lease sales, January 8, 1980*

Parcel	Acreage	Area	Company	Amount
13	2,280	Alvord	Anadarko	$236,367.60
14	2,463	Alvord	Anadarko	90,605.33
33	1,029	Breitenbush	Union Oil	10,341.45
39	118	Klamath Falls	Intercontinental	917.53
50	2,371	Crump	Hunt Oil	4,833.35
51	2,344	Crump	Hunt Oil	4,828.58

RESEARCH

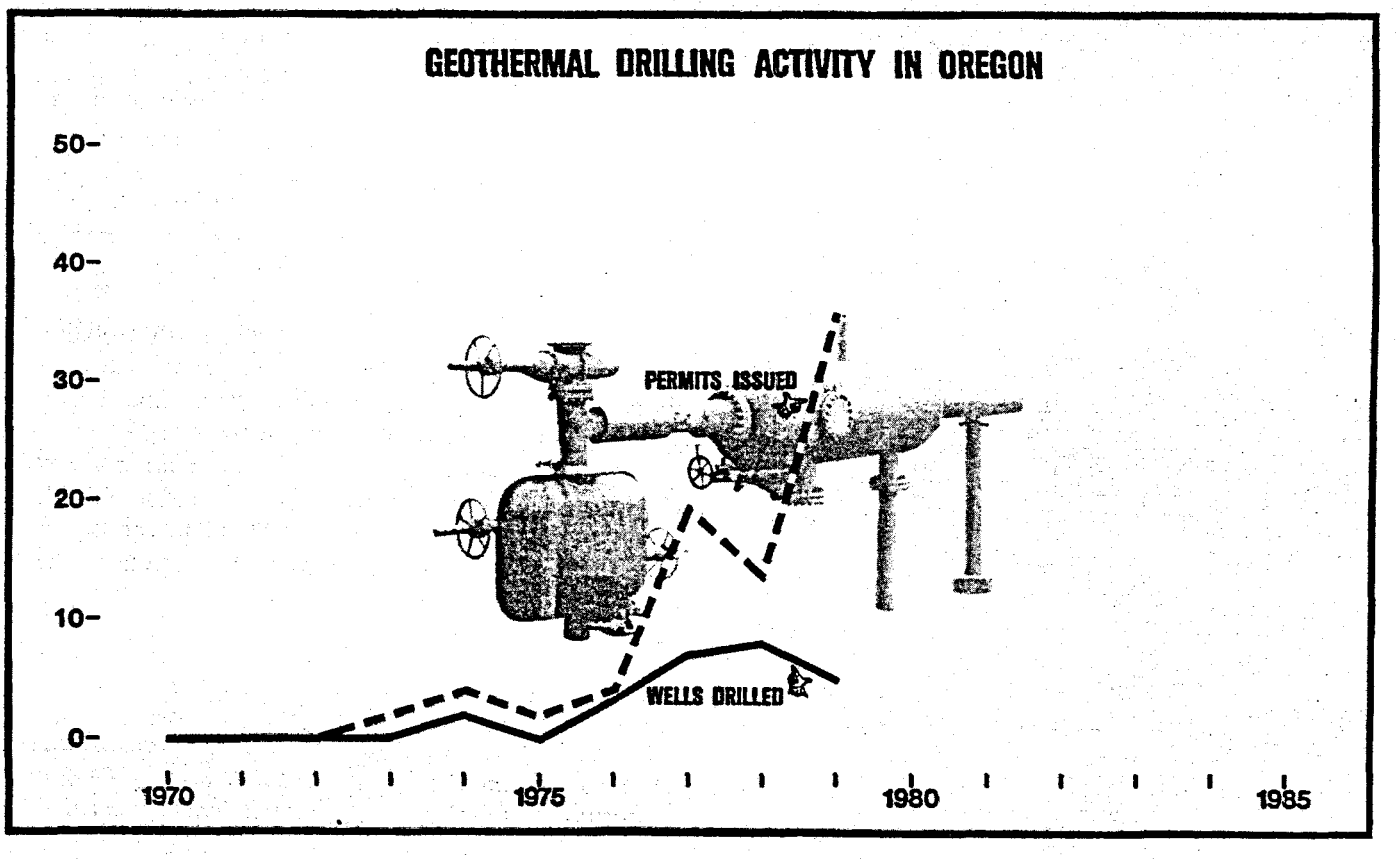
Low-temperature geothermal resources

The first phase of the statewide inventory of low-temperature geothermal resources (geothermal waters with a temperature of 90°C or less) was begun by the Oregon Department of Geology and Mineral Industries (DOGAMI) in July 1977 and completed in June 1979. The inventory consisted of two parts: (1) a compilation of chemical data on thermal springs and wells in Oregon, and (2) an identification of potential low-temperature resource areas on the basis of geochemical, temperature-gradient, heat-flow, geological, and geophysical data. These studies were funded by USDOE.

Forty-seven chemical analyses of thermal waters from Oregon springs or wells, based on both field sampling and literature research, were submitted to the USGS for inclusion in their GEOTHERM data base. These data and 142 others by the USGS are included in Open-File Report 0-79-3, *Chemical Analyses of Thermal Springs and Wells in Oregon*, authored jointly by USGS and DOGAMI. The locations of these thermal springs and wells, as well as others previously identified by DOGAMI, are shown on the Geological Map Series map GMS-10 (1978), which is an update of previously published Miscellaneous Paper 14, *Thermal Springs and Wells in Oregon* (1970).

During the second part of the study, thirty potential geothermal-field areas were identified, and pertinent data about them submitted to the USGS for inclusion in

Figure 3. Geothermal drilling activity in Oregon, 1979.



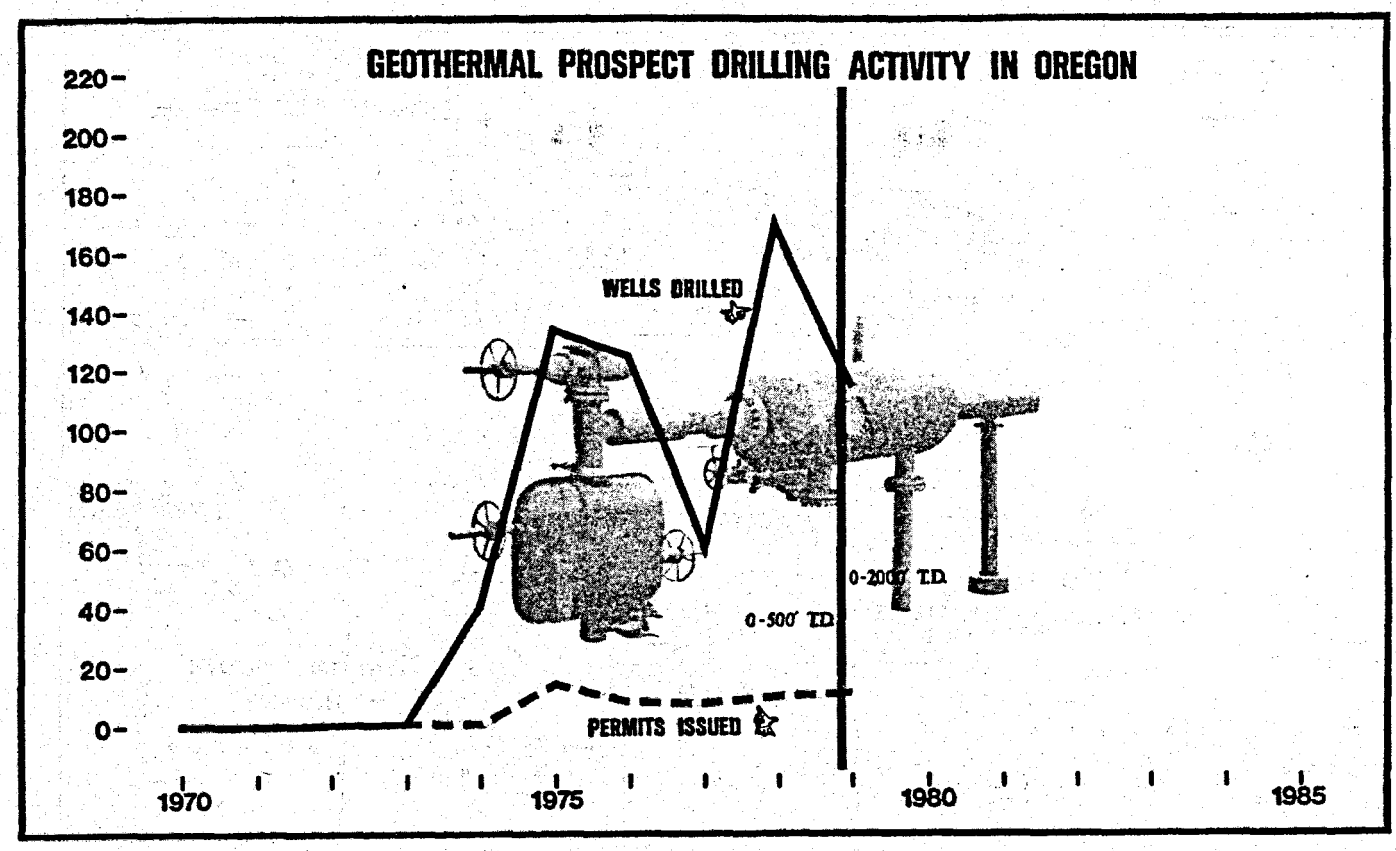


Figure 4. Geothermal prospect drilling activity in Oregon, 1979.

the GEOTHERM data base. Of these areas, nine that are totally in Oregon and three that are partially in Oregon-Idaho, Oregon-Nevada, and Oregon-Washington are favorable for the potential development of low-temperature geothermal resources and are detailed in USGS Circular 790, *Assessment of Geothermal Resources of the United States—1978* (1979). These areas are Belknap-Foley Hot Springs, Willamette Pass, Craig Mountain-Cove (La Grande), Glass Buttes, Northern Harney Basin, Southern Harney Basin, Alvord Desert, Lakeview, Klamath Falls, Western Snake River Basin, McDermitt, and Walla Walla.

Completion of the initial phase of the low-temperature study led to two major Department publications in 1979. GMS-11, *Preliminary Geothermal Resource Map of Oregon* (scale 1:500,000), relates the aforementioned resource areas to pertinent Pleistocene-Holocene geology, geologic structure, heat flow, and thermal springs and wells. Special Paper 4, *Heat Flow of Oregon*, contains extensive newly acquired heat-flow and geothermal-gradient data for the State. These data are presented on a contour map of heat flow (20 mW/m² interval) at a scale of 1:1,000,000. The text also contains maps of heat flow and temperatures at a depth of 1 km for 1° × 1° intervals. Histograms and averages of geothermal gradient and heat flow for the various physiographic provinces within the State are also included.

The second phase of the low-temperature study, site evaluation, which commenced in 1979 also through a USDOE contract, consists, in part, of geologic mapping by DOGAMI of the Belknap-Foley Hot Springs area (one 15-minute quadrangle), Willamette Pass area (two 15-minute quadrangles), Lakeview area (portions of three 15-minute quadrangles), and Northern and Southern Harney Basins (four 15-minute quadrangles) (Figure 5). Mapping is in various stages of completion. Mapping of the Craig Mountain-Cove (La Grande) area by Geoscience Research Consultants of Moscow, Idaho, under contract to DOGAMI, has been completed, and results of the study will be published as Special Paper 6 in 1980. The four 7½-minute quadrangles covered by this study include the southwestern portion of the Grande Ronde Valley and adjacent uplands.

Eight temperature-gradient holes were drilled to a maximum depth of 400 ft in the Lakeview area (Figures 6 and 7). Thermal waters collected from springs, wells, and temperature-gradient holes were analyzed, and chemical data were submitted to USGS for inclusion in the GEOTHERM data base.

The westerly two of the four temperature-gradient holes programmed for the La Grande area were drilled in 1979 (Figure 8). Chemical analysis of thermal waters collected from the area's thermal springs and wells is currently under way.

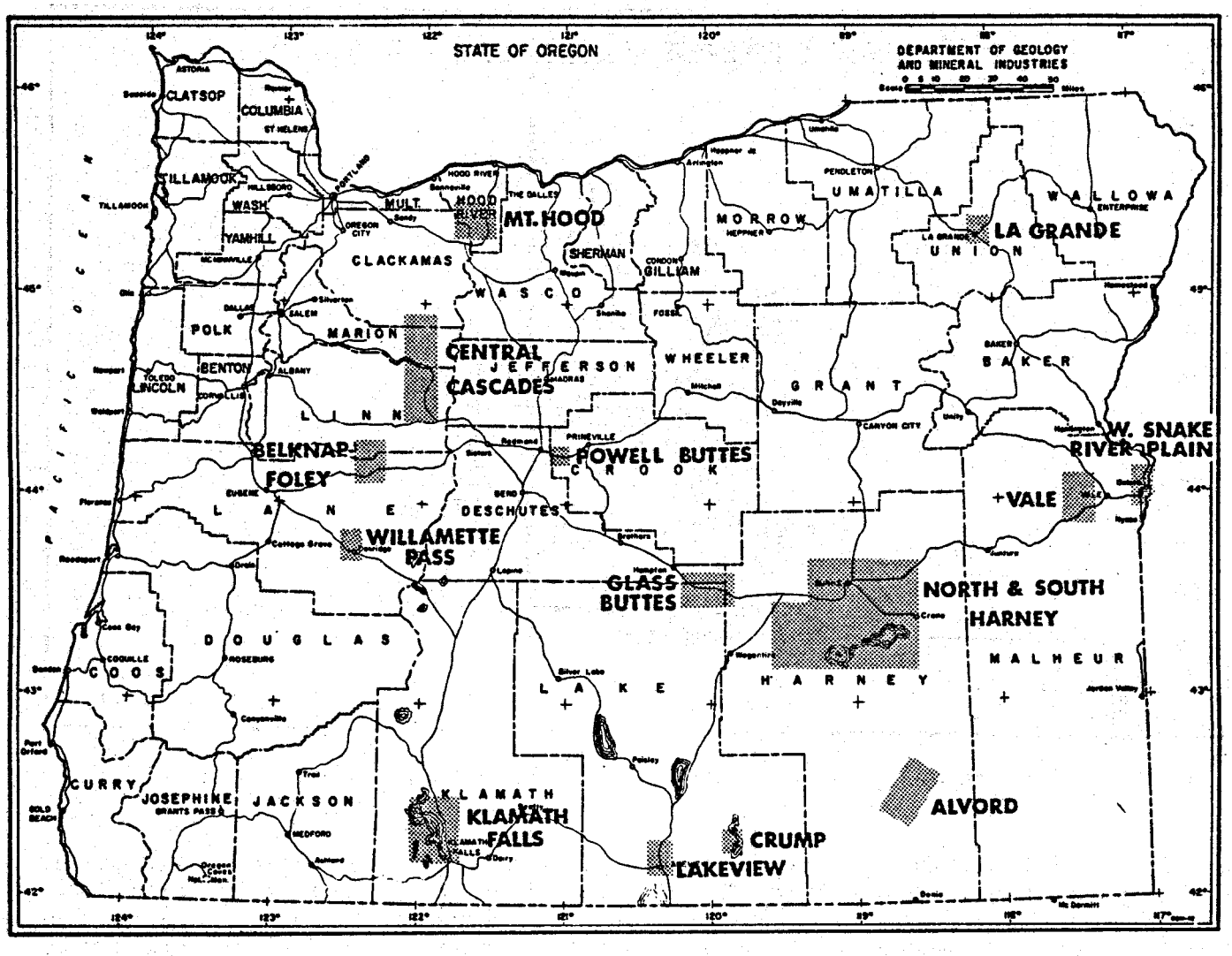


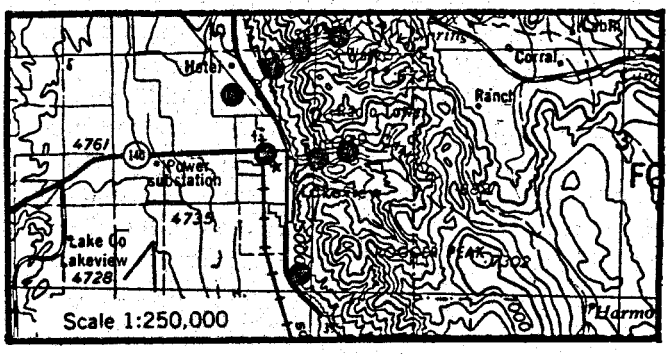
Figure 5. Areas of geothermal activity in Oregon, 1979.

Cascades study

The Department, through a USDOE contract, has initiated a temperature-gradient investigation of the Western and High Cascades of central Oregon. This project should be completed in late 1980. Eight holes up to 500 ft deep (Figure 2) were drilled during 1979; the remaining fourteen (not shown on map) are to be drilled in 1980. Geologic mapping, approximately 1 sq mi in extent, has been completed at each site drilled.

Also, as part of this overall project, several subcontracts to universities have been issued by DOGAMI. Richard Couch and Michael Gemperle, School of Oceanography, Oregon State University, will initiate aeromagnetic and gravity measurements in both the southern and northern Oregon Cascades. Craig White, Department of Geology, University of Oregon, is compiling a stratigraphic, structural, and petrological index of the Breitenbush 15-minute quadrangle and that area included in the drainage of the upper portion of the Molalla River in the northern part of the Mill City 15-minute quadrangle. The tectonic framework of the Western Cascades as deduced from paleomagnetic determination of microplate boundaries is the object of the research activity conducted by Allan Cox, Department of Geophysics, Stanford University. Cyrus Fields, Department of Geology, Oregon State University, will identify fossil hydrothermal systems in the Western Cascades.

Figure 6. Location of temperature-gradient holes, Lakeview area, Oregon.



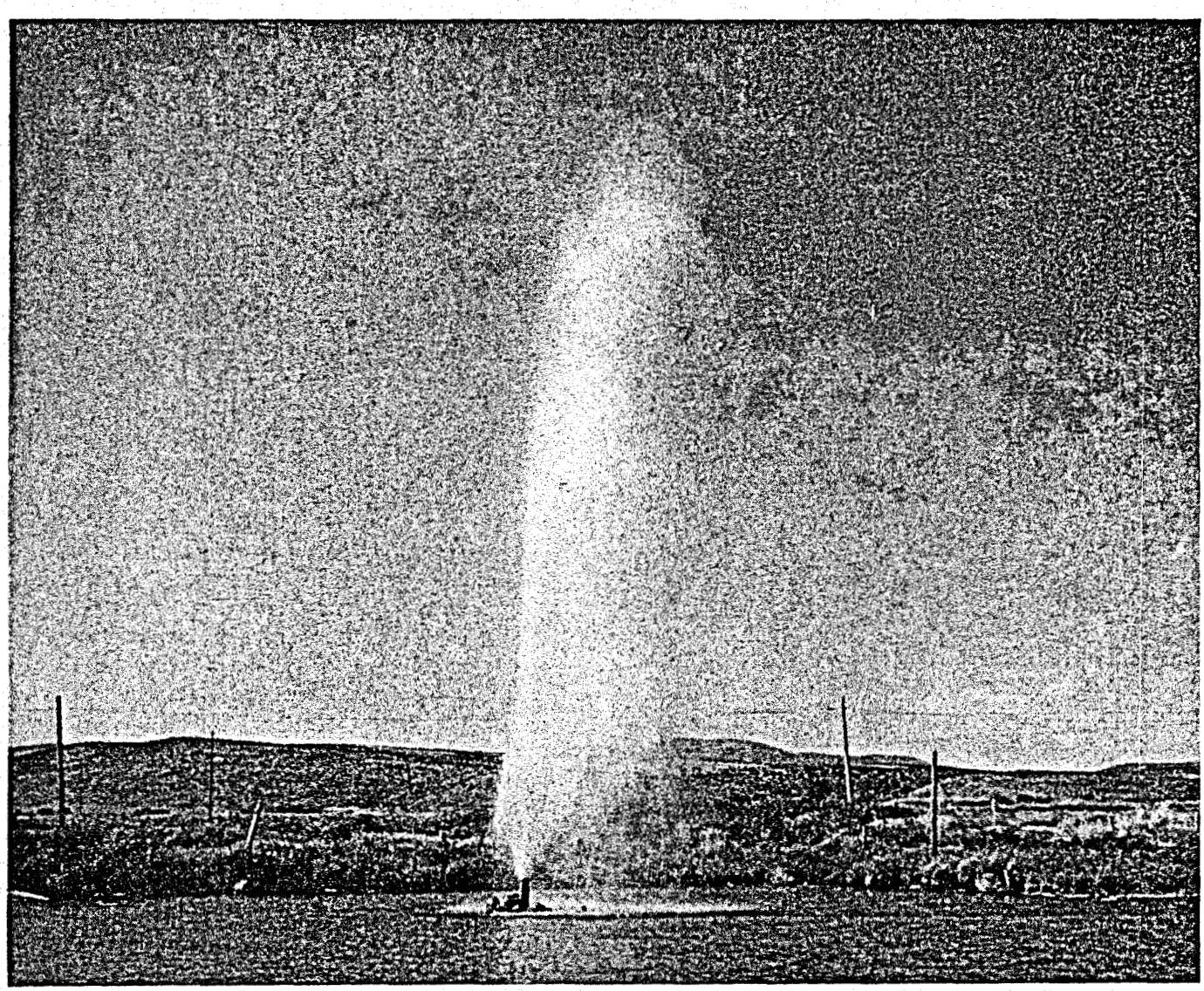


Figure 7. Hunter Hot Springs "Geyser," located north of the city of Lakeview, began erupting in October 1923 while a well was being drilled at this site.

U.S. Geological Survey

As part of the continuing Mt. Hood geothermal assessment program, the USGS has drilled four temperature-gradient holes (Tables 1 and 2) on the south and west flanks of Mt. Hood to a maximum depth of 2,000 ft. The hole at the base of the Pucci Chairlift (35S/9E-7ad) is to be deepened to approximately 3,000 ft in the summer of 1980.

Detailed field mapping and petrological and mineralogical studies of selected areas of hydrothermal alteration associated with active and fossil geothermal systems in the Western and High Cascades was initiated by the USGS in 1979 and will continue into 1980.

The July 1979 issue of *Oregon Geology* (v. 41, no. 7) contains a complete listing of all USGS geothermal research programs relating to the Cascade Range of Oregon.

Oregon Institute of Technology

The Geo-Heat Utilization Center at OIT reports that under the Federal technical assistance program the Center can provide up to 100 hours of free geothermal consultation. The program is intended to provide assistance to persons with little or no experience in geothermics in order to promote the rapid development of geothermal resources.

Other studies in which the Center is currently involved include an inventory and study of potential uses of geothermal resources in Oregon, Washington, Idaho, Montana, Alaska, and Wyoming; a study for the Bonneville Power Administration (BPA) to determine the potential for additional production of electricity through the use of geothermal energy in the BPA service area; an aquaculture project whereby prawns are raised in geothermal waters from existing wells on the geo-

LEGAL AND INSTITUTIONAL FRAMEWORK

FOR GEOTHERMAL DEVELOPMENT

IN OREGON

Establishing the necessary legal foundation and complying with applicable laws and regulations are interwoven into almost every stage of transforming a geothermal project from conceptual plan to actual utilization.

The following materials outline the general steps necessary to gain access to, explore for, develop, distribute, and use geothermal resources from private, local government, state, and Federal lands in Oregon. Specific details regarding the various steps of the permitting and approval process can be obtained from the appropriate Federal, state, and local agencies.

At the very outset of the project, comprehensive plans should be made for timely compliance with applicable laws, regulations, and permitting procedures, each of which has a different regulatory processing period, so that development can proceed expeditiously. In addition, the developer must comply with the laws and regulations not covered in this summary which apply to any business enterprise with respect to such matters as licenses and permits, employee relations and safety, operating procedures, taxation, and so forth.

OBTAINING ACCESS TO GEOTHERMAL RESOURCES

The geothermal developer must identify and secure all resource rights required for the proposed project. This task is not as simple as it may appear since geothermal resources are akin to water, to gases, and to minerals, and the right to the mineral estate in land may be separated from surface ownership. This complexity makes it difficult to relate geothermal to other established resource categories. Existing water rights, mineral titles, and surface and subsurface estates form an intricate tangle, and attachment of geothermal rights to one of them will disturb the rest.

These concerns are involved, to some extent, whether the proposed project is to be on private, local government, state, or Federal lands. In any case, a competent title search and ownership determination is essential to secure the necessary development rights. It is best to consult a qualified attorney. Additional information about water rights is set forth in the section on Production, Distribution, and Use.

Private Land

Access to private land can be obtained by purchase, lease, permit, option, or any other mutual agreement with the owner of the geothermal resource. In most instances, access to private land is obtained through a geothermal lease. Leasing terms generally include length of lease, royalty payments, lease fees, and stipulations governing exploration and development activities. This mechanism is often based on oil and gas leasing procedures. The geothermal developer would be well advised to make satisfactory arrangements with all parties interested in the land, including surface owners and users, owners of the geothermal and other mineral estates, and appropriators of water in the area.

City, County, and Local Special Purpose Government Land

Essentially the same considerations involved in obtaining access to private land apply securing geothermal interests in lands of local governmental entities. Some of these jurisdictions may prefer to or may be required to use a bidding process, rather than negotiation, to grant interests in their geothermal resources. Some may not be able to grant such interests. Information may be obtained from executive office of city,county or other local government.

State of Oregon Land

The State Land Board, through the Division of State Lands, is authorized to issue leases for geothermal resources underlying state-owned lands. A geothermal resources lease is required to explore, develop, or dispose of any state-owned geothermal resources. However, casual exploration activities can be carried out before lease acquisition under a geothermal exploration permit issued by the Division of State lands.

Generally, applications are accepted on a first come, first served basis. Leases may be issued by application or public drawing on noncompetitive land. The Division administers cash bonus bid leases on competitive lands classified as a Designated Geothermal Resource Area based on geologic evidence and/or a producing geothermal well.

The applicant is required to submit, within 120 days of filing the application; a geologist's preliminary survey report and ground water report, environmental impact report, evidence of compliance with insurance requirements, corporate surety bond, copies of permits issued by state or local regulatory agencies, and any other information required by the Division of State Lands.

There is no limitation on maximum lease size or total state holdings, but leases must cover a minimum of 40 acres. State geothermal leases are for a term of ten years and so long thereafter as resources are produced, up to 50 years. There are annual rental fees until production begins, and royalties are 10% of the gross value of the resource produced.

For additional information contact:

Division of State Lands
Minerals Leasing Specialist
1445 State Street
Salem, Oregon 97310
(503) 378-3805

Federal Land

Surface access and the rights to explore, develop, and use geothermal resources on federal lands are acquired with a geothermal lease issued by the U.S. Bureau of Land Management (BLM). Limited exploration involving casual-use activities and other preliminary evaluation operations may be conducted before securing a lease by obtaining a temporary use permit from the local BLM District Office or the Forest Supervisor's Office. Casual use refers to activities such as geologic mapping that are transitory and do not appreciably disturb the land.

The Bureau of Land Management has primary responsibility for issuing leases on all available Federal lands. The U.S. Geological Survey provides imput with respect to geologic matters and the environmental impact of geothermal operations. The U.S. Forest Service also has responsibilities concerning the surface environmental impact of geothermal activities on national forest lands.

The procedure for obtaining a federal geothermal lease depends upon the competitive interest classification of the land. Lands may be classified as "Known Geothermal Resource Areas" (KGRA) and leased on a competitive bid basis. Non-KGRA acreage is offered through a noncompetitive lease to the first qualified applicant. In Oregon, about 431,000 acres have been classified as KGRA lands.

Federal geothermal leases cover between 640 and 2,560 acres for a term of ten years and so long thereafter as resources are produced, up to 40 years. These time periods may be extended under certain circumstances. There are annual rental fees until production begins, and royalties are between 10% and 15% of the value of the resource produced.

For additional information, copies of applicable rules and regulations, and application forms, contact:

Bureau of Land Management
State Office
Minerals Leasing Section
729 N.E. Oregon Street
Portland, Oregon 97232
(503) 231-6291

U.S. Forest Service
Regional Office
Mineral Leasing Section
319 S.W. Pine
Portland, Oregon 97204
(503) 221-2877

U.S. Geological Survey
Office of the Area Geothermal Supervisor
345 Middlefield Rd., MS 92
Menlo Park, Calif. 94025
(415) 323-8111

EXPLORATION AND DEVELOPMENT

After obtaining clear title for a particular geothermal resource, but before initiating any activity, the geothermal developer must obtain the necessary permits from the appropriate local, state, and federal regulators. The length of permit application review time and the number and type of permits required will vary depending upon the size of the project and the environmental sensitivity of the area.

The following section describes the general types of permits that may be required. It is suggested that the developer contact the local, state, and federal agencies which may have regulatory authority for a specific project for additional details. The Oregon Department of Energy also can provide information regarding permitting requirements for a particular project.

Local Regulation

Conditional land use permits may be required for well drilling from cities or counties in compliance with local zoning ordinances and Land Conservation and Development Commission goals and guidelines. Contact the local planning department for information regarding applicable laws and regulations.

Construction permits and building inspections to insure compliance with state and local codes should be coordinated through the local building and safety authorities. In addition, leases providing access to local government lands, or city franchises, may contain special stipulations with respect to drilling activities.

State Regulation

The state regulates well drilling regardless of land ownership. In Oregon, regulatory responsibilities for geothermal resources are divided between two state agencies; Department of Geology and Mineral Industries (DOGAMI) and Department of Water Resources (DWR). DOGAMI regulates geothermal prospect and geothermal wells. Shallow (less than 2,000 feet) low-temperature (under 250°F.) wells are regulated by DWR, essentially in the same manner as common water wells.

If the intent is to explore for and produce geothermal fluids with temperatures of 250°F. or greater, then the necessary permits are obtained from DOGAMI. The agency issues prospecting permits which may cover numerous gradient wells 2,000 feet deep or less.

For more information concerning geothermal wells contact:

Department of Geology & Mineral Industries
1064 State Office Building
Portland, Oregon 97201
(503) 229-5580

For more information concerning shallow, low-temperature wells contact the local Watermaster or:

Department of Water Resources
Mill Creek Office Park
555 13th Street N.E.
Salem, Oregon 97310
(503) 378-3739

A permit may be required from the Department of Environmental Quality (DEQ) for the disposal of liquid wastes such as drilling muds, equipment oils, geothermal fluids, and solid wastes. A permit also may be required from DEQ for air emissions, and DEQ administers noise regulations. For more information contact:

Department of Environmental Quality
P.O. Box 1760
Portland, Oregon 97207
(503) 229-5696

Other regulations may be applicable in special circumstances, such as the necessity to obtain oversize load permits for transporting large drilling rigs on state highways and county roads.

In addition to the foregoing requirements, for geothermal resource exploration and development to occur on state land, the Division of State Lands requires: a proposed testing program, certified copies of all tests and measurements, legal confirmation of the well's primary purpose, design alternatives considered in development planning, and measurements of the quality and quantity of all production.

Federal Regulation

When BLM has issued the lease on federal lands, the U.S. Geological Survey assumes primary responsibility for exploration and development operations within the federal lease area. The surface managing agency is responsible for all other aspects of the lease.

Activities related to geothermal resource exploration, development, production, and utilization are carried out under a Plan of Operation approved by the USGS. Necessary permits and environmental reviews are coordinated by the USGS with the exception of permits required for emissions to the atmosphere and waste disposal which are issued by the State Department of Environmental Quality. The developer also must obtain a well drilling permit from the Oregon Department of Geology and Mineral Industries. Plans of operation may be submitted sequentially by development phases or in combination, depending upon project scale and developer's data.

Federal agencies, generally the surface management agency and the USGS, are responsible for the preparation of environmental documents necessary to satisfy requirements of the National Environmental Policy Act and state or local environmental laws for activities conducted on federal land. State and local regulations are applicable to federal lands, but these standards are generally enforced by federal agencies.

PRODUCTION, DISTRIBUTION, AND USE

The roles and jurisdiction of the local and state agencies outlined under the preceding section on exploration and development carry over with respect to production, distribution, and use activities. Before discussion of additional state and federal regulatory requirements, it is appropriate to consider the impact of water right laws on geothermal development.

Water Rights

All water from all sources of supply belongs, by law, to the public, and the right to use water is subject to existing rights and legislative and administrative withdrawals. Water may be appropriated by beneficial use on a first-in time, first-in right basis in compliance with the provisions of the state water code.

Many legal questions concerning possible conflicts between the right to use water for geothermal heat extraction and traditional beneficial uses of water have not been answered. Accordingly, a geothermal developer should be concerned about the availability of a water right of sufficient quantity to satisfy project needs from the outset and should file an application to appropriate water with the Department of Water Resources during the initial planning stages.

Local Regulation

In addition to the areas of local regulation set forth in the preceding section, which also apply to production, distribution, and use, a franchise may be necessary for the operation of an energy distribution system within an incorporated area, and permission must be obtained for the placement of facilities on county road and state highway rights-of-way. Easements over private lands also may be necessary.

Oregon has adopted model legislation enabling communities to form publicly-owned geothermal heating districts to develop and beneficially manage local geothermal resources. Information about the formation of geothermal heating districts may be obained from the Oregon Department of Energy.

State Regulation

The Department of Geology and Mineral Industries regulates production from and abandonment of geothermal wells as well as such matters as pooling of geothermal interests. Department of Environmental Quality (DEQ) standards concerning air and water quality, noise, and waste disposal also apply to production, distribution, and use activities. Division of State Lands supervision of production activities on state lands also continues.

Oregon policy requires that all geothermal fluids be injected into the same reservoir from which withdrawn unless it is determined by the agency responsible for well permitting that disposal by other means is in the public interest. Legislation outlining this policy specifically mentions that disposal by other means includes secondary uses of fluids produced from electrical generation and direct applications for such uses as plant cooling, and agricultural, commercial, or industrial purposes.

A permit from DEQ is required if pollutants are added to the fluid prior to injection into the same aquifer or if injection into an aquifer of superior quality will occur. A DEQ permit always is required for disposal of geothermal fluids by any method other than injection.

The Oregon Energy Facility Siting Council (EFSC) maintains siting jurisdiction for certain energy facilities on all private, state, or federally owned lands. Site certificates are required for certain power plants and pipelines transporting geothermal fluids. The EFSC has the power to conduct investigations into all aspects of site selection, designate areas within the state as suitable or unsuitable for geothermal power plants, and to establish standards and promulgate rules which must be satisfied in order to obtain a site certificate.

A site certificate authorizes the applicant to construct and operate a geothermal facility under conditions set forth in the certificate. The signed certificate binds the state and all affected political subdivisions to the approval of the site for construction and operation of the facility. All necessary permits and licenses must be issued, subject only to the conditions of the site certificates.

If geothermal energy or electricity is to be distributed to other parties, then the developer may become a public utility subject to comprehensive regulation by the Public Utility Commissioner with respect to rates, characteristics of service, operating procedures, financial condition, and related matters.

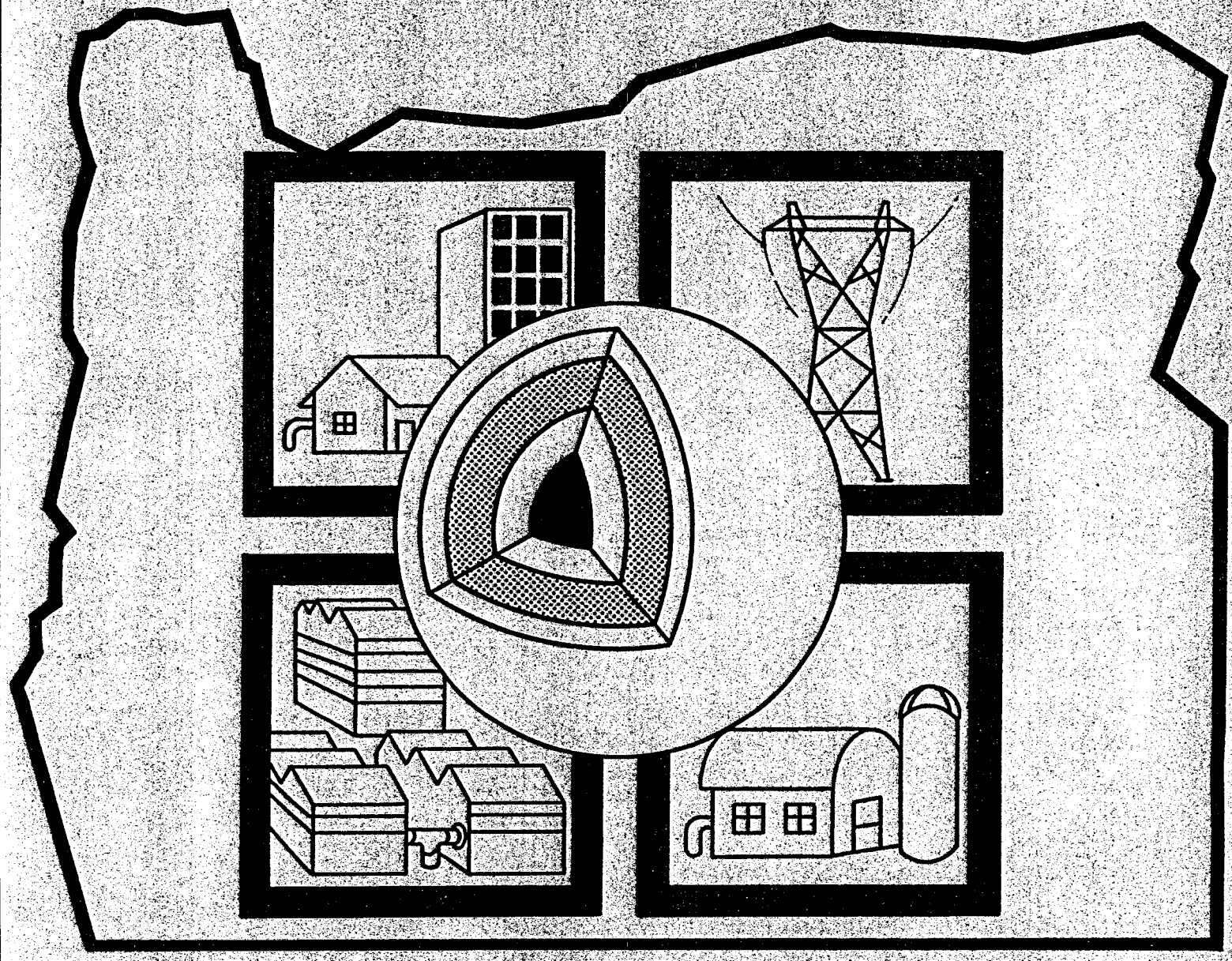
The Department of Commerce promulgates and enforces numerous building and safety codes which apply to all facilities including those that produce, distribute, and use geothermal energy.

Federal Regulation

Resource production on Federal land is regulated by the U.S. Geological Survey (USGS) by means of an approved Plan of Production. Before the plan is approved, the applicant must gather environmental baseline data describing the existing environmental setting for a one-year period, unless the requirement is waived because the project will have minimal impact. It is important for the developer to have an early consultation with the USGS to determine which requirements will apply to a specific project to facilitate planning of sufficient time and labor allocation.

Small scale facilities on federal land are permitted on a case-by-case basis by USGS, and environmental evaluations are undertaken if necessary. Larger facilities, such as electric generating plants, are licensed and reviewed for environmental impact by the BLM in consultation with USGS. The basic permit for facility siting covers activities only on the lease area. Transmission or distribution lines or any other off-lease facility involves separate permitting procedures.

OREGON



GEOTHERMAL

DIRECT UTILIZATION & ECONOMICS

GEOTHERMAL RESOURCE UTILIZATION

Paul J. Lienau

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Oregon Institute of Technology, Klamath Falls, Oregon
Presented to AAAS Annual Meeting
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ABSTRACT

Man has utilized the natural heat of the earth for centuries. Worldwide direct use of geothermal currently amounts to about 7,000 MW_t, as compared to 1,500 MW_e, now being used for the generation of electricity. Since the early 1970s, dwindling domestic reservoirs of oil and gas, continued price escalation of oil on the world market and environmental concerns associated with coal and nuclear energy have created a growing interest in the use of geothermal energy in the United States. The Department of Energy goals for hydrothermal resource utilization in the United States, expressed in barrels of oil equivalent, is 50 to 90 million bbl./yr. by 1985 and 350 to 900 million bbl./yr. by the year 2000. This relatively clean and highly versatile resource is now being used in a multitude of diverse applications, e.g., space heating and cooling, vegetable dehydration, agriculture, aquaculture, light manufacturing, and other applications requiring a reliable and economic source of heat.

SUMMARY OF UTILIZATION

The direct use of geothermal resources has been practiced internationally for centuries. Recorded history shows uses by Romans, Chinese, Japanese, Turks, Icelanders, Central Europeans, and the Maori of New Zealand for bathing, cooking, and space heating. Today, worldwide, more than 7,000 MW_t (thermal) of geothermal energy are used for residential and commercial space heating and cooling, agriculture and aquaculture, and industrial processing.

Space heating generally utilizes temperatures in the range of 150° to 212°F, with 100°F being used in some marginal cases and heat pumps extending this range down to 55°F. The leading user of geothermal energy for space heating is Iceland, where over 50 percent of the country is provided with geothermal heat. The only known cooling is in Rotorua, New Zealand, at the International Hotel; however, many other applications are presently being considered.

Typically, the agriculture-related uses utilize the lowest temperatures, with values from 80° to 180°F being typical. Use of wastewater has wide applications here. The amount and types of chemicals and dissolved gases, such as boron, arsenic, and hydrogen sulphide, are a major problem for this use. Heat exchangers and proper venting of gases may be necessary in some cases to solve this problem. Almost all of the agricultural-related energy utilization is in the Soviet Union where over 5,000 MW_t is reported being used.

Industrial processing typically requires the highest temperature, using both steam and superheated water. Temperatures up to 300°F are normally desired; however, lower temperatures can be used in some cases, especially for drying of various agricultural products. Though there are relatively few examples of industrial processing use of geothermal energy, they represent a wide range of applications, from drying of wool, fish, earth and timber, to pulp and paper processing, and to chemical extraction. The two largest industrial uses are the diatomaceous earth drying plant in Iceland and the paper and wood processing plant in New Zealand.

Examples of Current Utilization

Traditionally, direct use of geothermal energy has been on a small scale by individuals. Surface hot springs were utilized and shallow wells could be justified with on-the-spot use or short transmission distances in uninsulated pipes or channels. However, at today's prices for development and hardware, the cost savings of these individual uses are often marginal. Large-scale use demands require more production and can thus justify deeper wells, longer transmission distances, more sophisticated utilization, and lower temperatures.

Most of present-day developments involve large-scale projects, such as district heating (Iceland), greenhouse complexes (Hungary), or major industrial use (New Zealand). Heat exchangers are also becoming more efficient and better adapted to geothermal use, allowing the use of lower-temperature waters and highly saline fluids. Heat pumps are extending geothermal development into traditionally nongeothermal countries, such as France, Austria, and Denmark, as well as the eastern United States.

Space Conditioning. The most famous space-heating project in the world is the Reykjavik municipal heating project, serving about 97 percent of the 113,000 people in the capital city of Iceland. At present, a total of 1.0×10^{10} gallons of geothermal fluid are used annually to supply 16,000 homes with space heating. One field supplies water through two 14-inch and one 28-inch diameter pipeline over a 12-mile distance. Insulated storage tanks (6.9×10^6 gallons) are used to meet peak flows and provide an emergency supply in the event of breakdown in the system. A fossil fuel-fired peaking station is used to boost the 176°F water to 230°F during 15 to 20 of the coldest days of the year. The city is served by 9 pumping stations, distributing fluid through 200 miles of pipelines. The entire system provides 1,840 GW_h per year or 420 MW_t (including the peaking station; Zoega, 1974).

An example of individual home space heating is in Klamath Falls, Oregon, where over 400 wells are used for space heating, using waters from 100° to 230°F. The principal heat-extraction system is the closed-loop downhole heat exchanger utilizing city water in the loop. Larger examples of space heating in Klamath Falls include the Oregon Institute of Technology campus, where three wells up to 1,800 feet deep produce up to 450 gpm of 192°F water and heat approximately 700,000 ft^2 of floor space. The geothermal water is pumped from the well using deep-well turbine pumps and, in most cases, is used directly in the heating system for each building. The annual operating cost of the campus system is approximately $30,000, a savings of almost $250,000 per year when compared with the cost of heating with conventional fuel. Other notable uses in the community include the 311-bed Merle West Medical Center hospital and nursing home, where the present worth of a 20-year savings due to a geothermal-retrofitted heating system is over one million dollars, and Maywood Industries, where 118°F water is used for heating a large manufacturing building.

Agriculture and Aquaculture. In Hungary, greenhouse heating is second only to the USSR, with over 13 million ft^2 being geothermally heated. Many of these greenhouses are built on rollers, so they can be pulled from their location by tractors, the ground cultivated with large equipment, and then the greenhouse returned to its location. In addition, to minimize cost, much of the building/structure pipe-supporting system also acts as the supply and radiation system for the geothermal fluid. About 60 wells are used for animal husbandry projects, mainly for heating and cleaning of animal shelters. Priority is given to agricultural use of geothermal energy in Hungary, as this increases the volume and variety of production.

Some experimental work is being performed with grain, hay, tobacco, and paprika drying. In these cases, hot water supplies heat to forced-air heat exchangers and 120° to 140°F air is blown over the product to be dried.

In Japan, greenhouses cover about 157,000 ft^2, where a variety of vegetables and flowers are grown. Many large greenhouses are operated as tropical gardens for sightseeing purposes. Raising poultry through the use of geothermal energy has been a very successful enterprise. Here, under-the-floor heating is utilized in sheds where 40,000 chickens are raised annually. Another successful business is breeding and raising carp and eels. Eels are the most profitable and are raised in 10-inch diameter by 20-foot long earthenware pipes. Water in the pipes is held at 73°F by mixing hot spring water with river water. The adult eels weigh from 3-1/2 to 5-1/4 ounces, with a total annual production of 8,400 lb. Alligators and crocodiles are also raised in geothermal water. These reptiles are being bred purely for sightseeing purposes. In combination with greenhouses offering tropical flora, alligator farms are offering increasingly large inducements to the local growth of the tourist industry.

Excellent examples of greenhouse operation exist in the United States, the largest being Geo-Products Corporation complex near Susanville, California. Cucumbers and tomatoes are grown in a hydroponic system. Heat is provided to the greenhouses by geothermal fluid. At present, 30 greenhouses have been constructed, with expansion planned to over 200 units. Channel catfish are raised by Fish Breeders of Idaho near Buhl, using geothermal water. Using 6,000 gpm of 90°F water, approximately 500,000 lbs. of fish are raised annually.

Industrial Processes. An example of industrial processing is the use of geothermal steam for the Tasman Pulp and Paper Company in New Zealand. Here, from 100 to 125 MW_t (18 tons/hr. steam) of thermal energy is used for the timber drying, black liquor evaporation, and pulp and paper drying. The total investment cost for geothermal is $6.8 million, the majority of which is for well development. This amounts to approximately $70 per KW_t and will reduce the price of energy to 70 percent that of conventional fuels for an annual savings of $1.3 million. The annual maintenance costs are 2 percent of the capital cost.

In northern Iceland, a diatomaceous slurry is dredged from Lake Myuata. This slurry is transported through a pipeline and held in storage ponds. The 80 percent moisture is then removed in large rotary-drum driers using high-temperature geothermal steam. The plant produces 27,000 tons of diatomite filteraids per year, most of which are used in beer processing in Germany.

Two industrial processing uses of geothermal energy are of note in the United States: Medo-Bel Creamery in Klamath Falls, where low-temperature fluid is used for pasteurizing milk, and Geothermal Food Processors at Brady Hot Springs, Nevada, where high-temperature fluid is used for dehydration of onions and other vegetables.

A major direct-thermal project in the U.S.A., in the development stage, is the conversion of the Ore-Ida Foods, Inc., plant located in Ontario, Oregon. The Ore-Ida project involves drilling three production wells to a depth of 6,000 feet to obtain 800 gpm at a temperature of 300°F. The geothermal energy would replace 55 percent of the energy now supplied by natural gas and fuel oil for potato processing.

A summary of the present worldwide direct use of geothermal energy is as follows:

TABLE 1

Worldwide Direct Use of Geothermal Energy

Country	Space Heating/ Cooling (MW_t)	Agriculture/ Aquaculture (MW_t)	Industrial Processes (MW_t)
Iceland	680	40	50
New Zealand	50	10	150
Japan	10	30	5
USSR	120	5,100	---
Hungary	300	370	---
Italy	50	5	20
France	10	---	---
Others	10	10	5
U.S.A.	75	5	5
TOTAL	1,245	5,570	235

DOE DIRECT-HEAT APPLICATIONS PROJECTS

To stimulate development in the direct-heat area, the Department of Energy, Division of Geothermal Energy, issued two Program Opportunity Notices. These solicitations are part of DOE's national geothermal energy program plan, which has as its goal the near-term commercialization by the private sector of hydrothermal resources. Encouragement is being given to the private sector by DOE cost, sharing a portion of the front-end financial risk in a limited number of demonstration projects.

The twenty-two projects are a direct result of the Program Opportunity Notice solicitations. These projects will (1) provide visible evidence of the profitability of various direct-heat applications in a number of geographical regions; (2) obtain technical, economic, institutional, and environmental data under field operating conditions that will facilitate decisions on the utilization of geothermal energy by prospective developers and users; and (3) demonstrate a variety of types of applications.

Conservatively, the energy savings from the projects amount to about one million barrels of oil per year on stream by 1981. Location of the projects is shown on Figure 1 and savings on Table 2.

TABLE 2

DOE Hydrothermal Applications Projects
Annual Energy Savings

Category	No. Projects	BTU/Year
District Heating	9	$3,478 \times 10^9$
Unit Space Heating	7	238×10^9
Agriculture/Aquaculture	4	490×10^9
Industrial Process Heating	2	$1,635 \times 10^9$
		$5,841 \times 10^9$

$\approx$ 1 Million Bopy
On-Stream by 1981

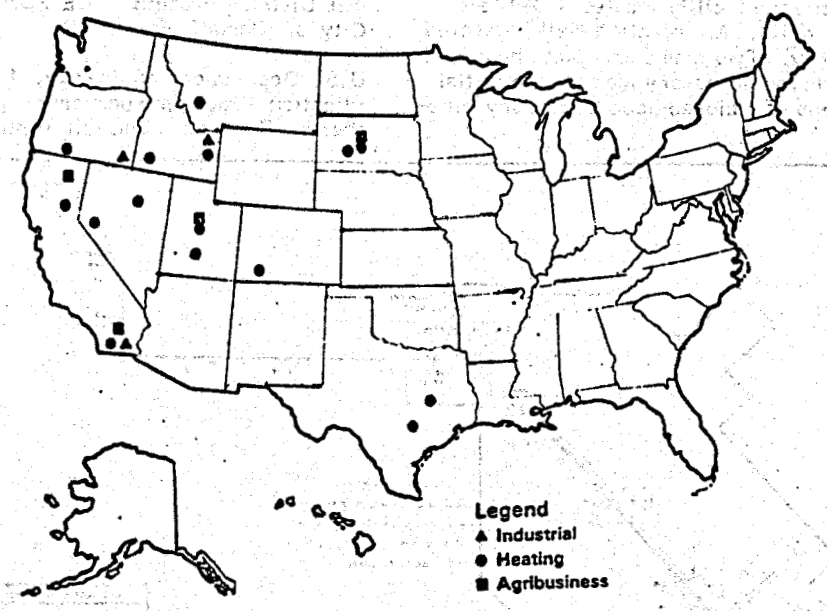


Figure 1. DOE Cost-Shared Direct-Heat Application Projects.

The goals of the U.S. Department of Energy for hydrothermal resource utilization by 1985 and the year 2000 are shown on Table 3.

TABLE 3

U.S. Goals for Hydrothermal Resources Utilization

	1985	2000
Electric Power (MW_e)	3,000-4,000	20,000-40,000
Direct-Heat Application (q/yr.)*	0.1-0.2	0.5-2.0
Total Thermal Energy (q/yr.)	0.3-0.5	2.0-5.0
Barrels of Oil Equivalent (10^6 bbl./yr.)	50-90	350-900

*q/yr. = 10^{18} BTU/yr.

CASE STUDY - KLAMATH FALLS GEOTHERMAL DISTRICT HEATING PROJECT

The City of Klamath Falls, Oregon, is constructing a geothermal district heating project that will supply 314 x 10^9 BTU/Year (40 MW_t peak demand) of heat to commercial buildings on 54 blocks. Initially, the system will heat 14 government buildings (Phase I) in the downtown area, subsequently expanded to heat 11 blocks (Phase II), and then to heat the entire 54-block central business district (Phase III).

Production wells will be drilled along the east boundary of the city, estimated to supply over 220°F water. A primary 10-inch diameter insulated steel pipeline, placed in a concrete duct, will supply geothermal fluid to a central heat exchange facility located 4,060 feet from the production wells. An injection well is located adjacent to this facility. Two frame and plate heat exchangers will provide the necessary load for the initial 14 buildings by means of a closed-loop secondary pipeline (5,780 feet) supplying heated water to the buildings at 200°F. This line will consist of buried insulated fiberglass, reinforced plastic pipe.

Figure 2 shows the district heating distribution network.

The capital cost of the project (Phase I) will be $1.4 million, giving an equivalent annual capital, operation, and maintenance cost over a 20-year period of $150,000. Phase II cost of geothermal energy is estimated at $2.90 per million BTU, whereas the equivalent annual fossil fuel cost is estimated at $9.40 per million BTU.

CONCLUSION

Direct utilization of geothermal energy for space and process heating, for the most part, utilizes known technology. Basically, hot water is hot water whether from a boiler or from the earth. The utilization of geothermal energy requires only straightforward engineering progress rather than revolutionary advances and major scientific discoveries. The technology, reliability, economics, and environmental acceptability have been demonstrated throughout the world.

REFERENCES

Anderson, David N., and John W. Lund, 1979, Direct Utilization of Geothermal Energy: A Technical Hand-Book, a Geothermal Resources Council, Davis, CA.

Lienau, Paul J., and John W. Lund., eds., 1974, Multipurpose Use of Geothermal Energy: proceedings of the International Conference on Geothermal Energy for Industrial, Agricultural, and Commercial-Residential Uses, Klamath Falls, Oregon Institute of Technology.

Lund, John W., et. al., 1979, Klamath Falls Geothermal District Heating, DOE PON EG-77-N-03-1553, City of Klamath Falls, OR.

U.S. Department of Energy, 1979, Direct-Heat Application Program Summary: presented at the Geothermal Resources Council Annual Meeting, Reno, NV.

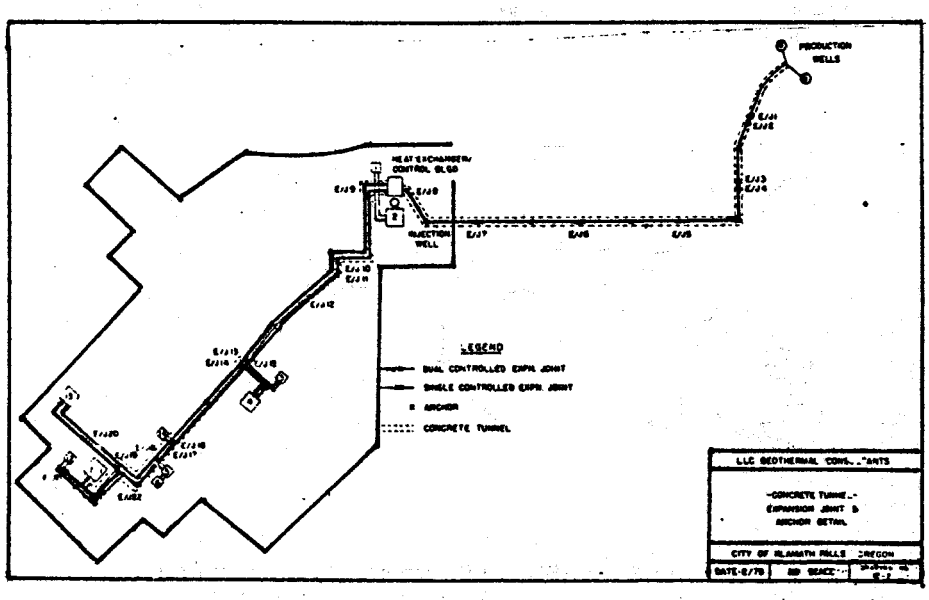
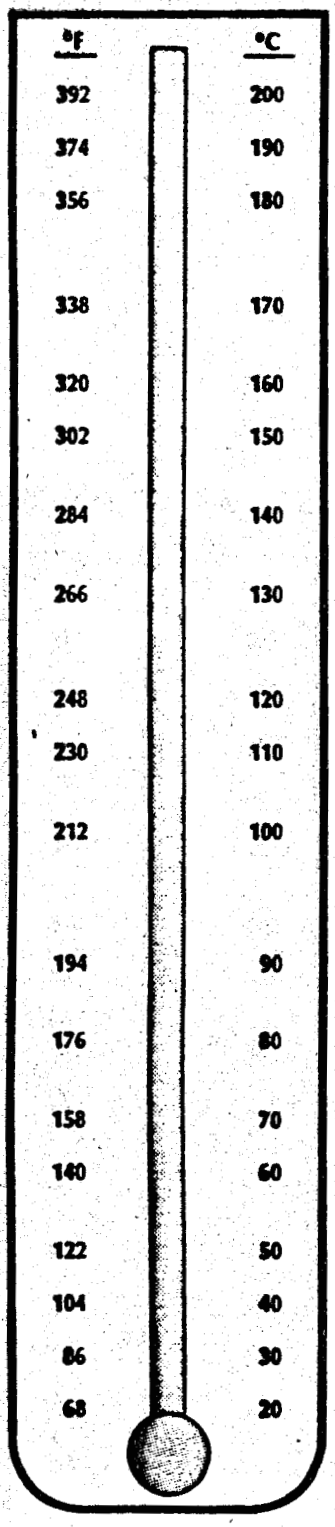


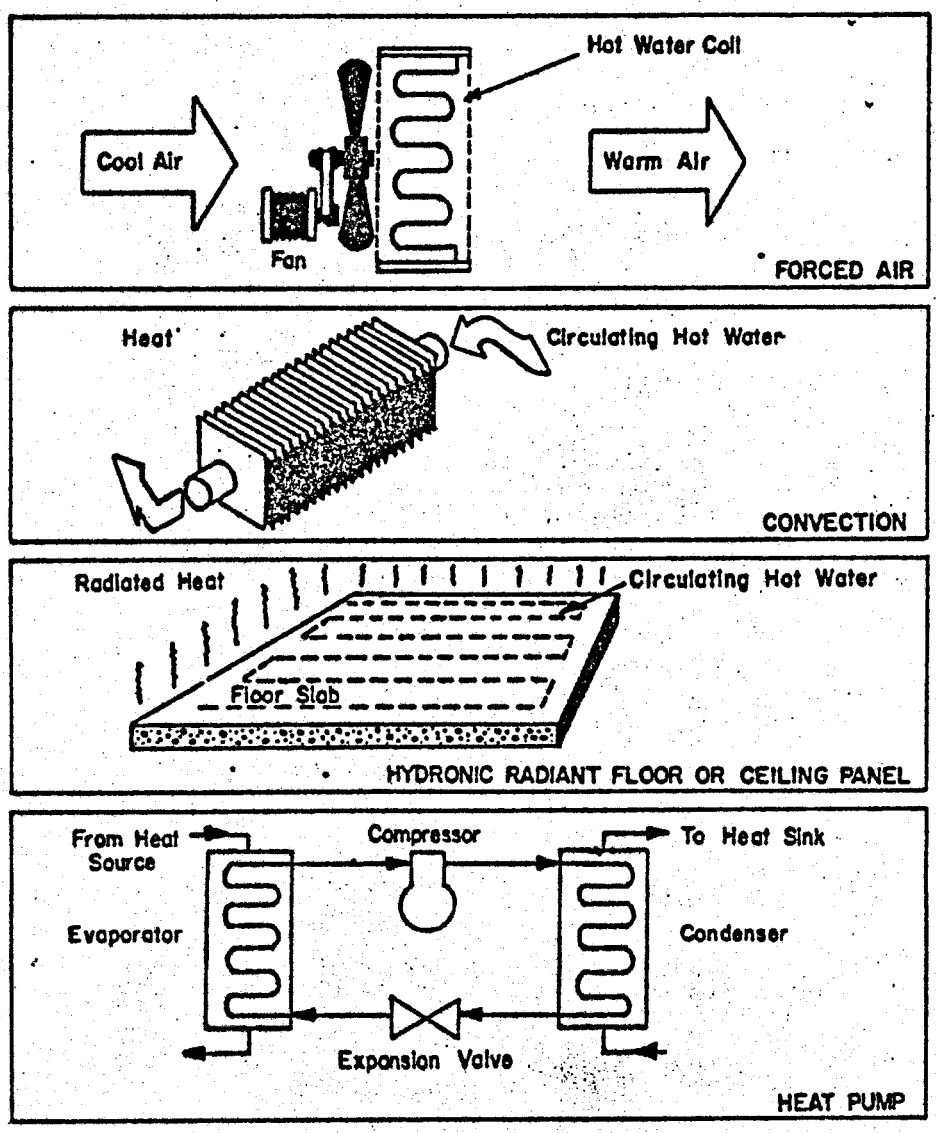
Figure 2. Klamath Falls Distribution Network

GEOTHERMOMETER

DIRECT HEAT APPLICATIONS OF GEOTHERMAL ENERGY



°F	°C	
392	200	Deep fat frying
374	190	
356	180	Evaporation of highly concentrated solutions Refrigeration by ammonia absorption Digestion in paper pulp. Kraft process
338	170	Heavy water by hydrogen sulphide process Drying diatomaceous earth
320	160	Drying fish meal. Drying timber
302	150	Beet sugar processing Alumina through Bayers process
284	140	Drying farm products at high rates Food canning
266	130	Evaporation in sugar refining Extraction of salts by evaporation and crystallization
248	120	Fresh water by distillation
230	110	Drying and curing light aggregate cement slabs Saline solutions for intravenous injection
212	100	Dehydrated potato processing Drying organic materials, seaweed, grass, vegetables, etc. Washing and drying wool
194	90	Drying stock fish Intense deicing operations
176	80	Space heating—domestic, greenhouses Milk pasteurization
158	70	Refrigeration by low temperature
140	60	Animal husbandry, space heating, hotbed heating Manure processing, poultry processing, cheese mfg.
122	50	Poultry hatching, brooding. Mushroom growing
104	40	Soil warming
86	30	Biodegradation, fermentations, deicing
68	20	Fish hatching/farming



Space-heating systems suitable for geothermal applications

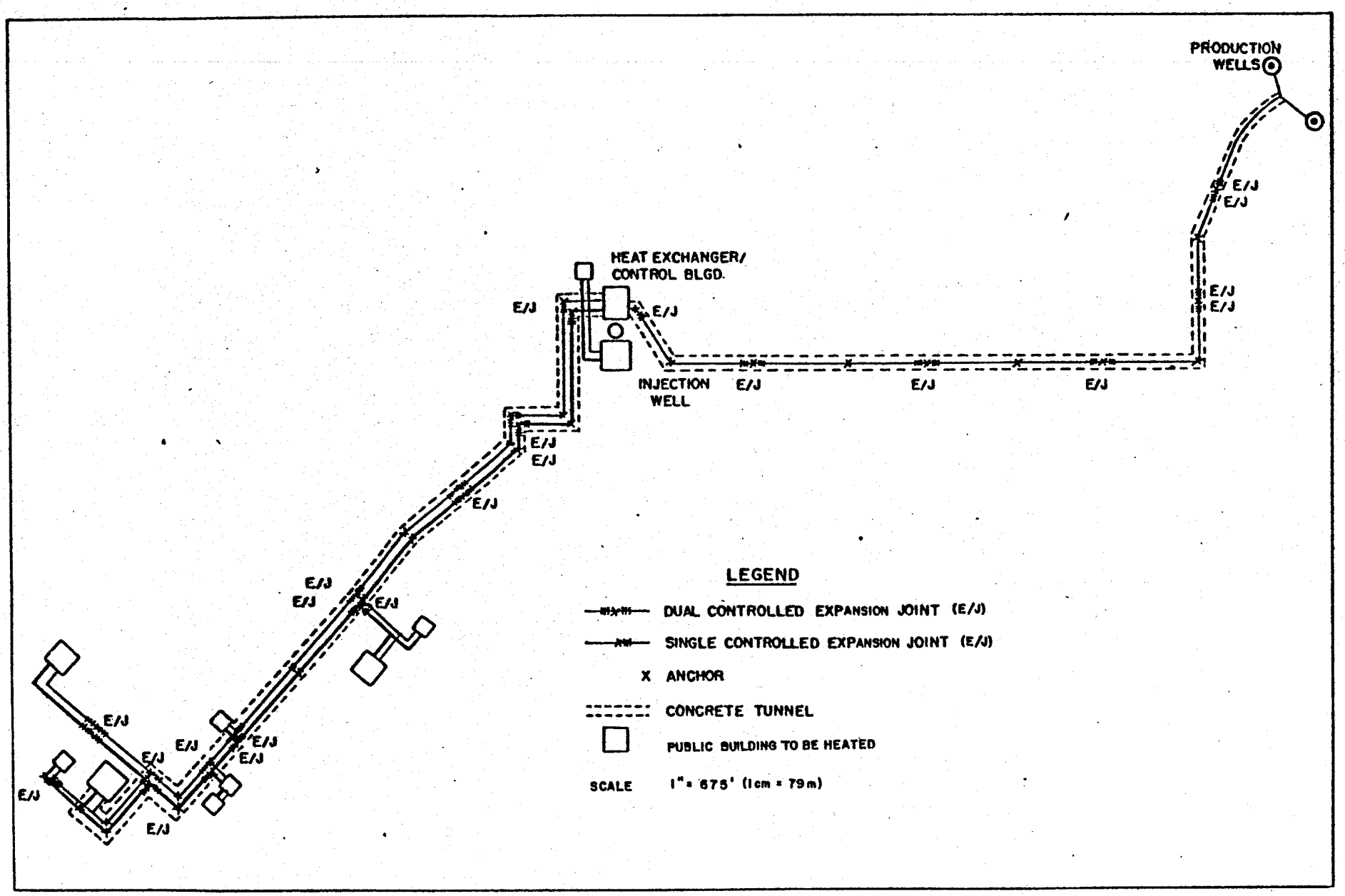
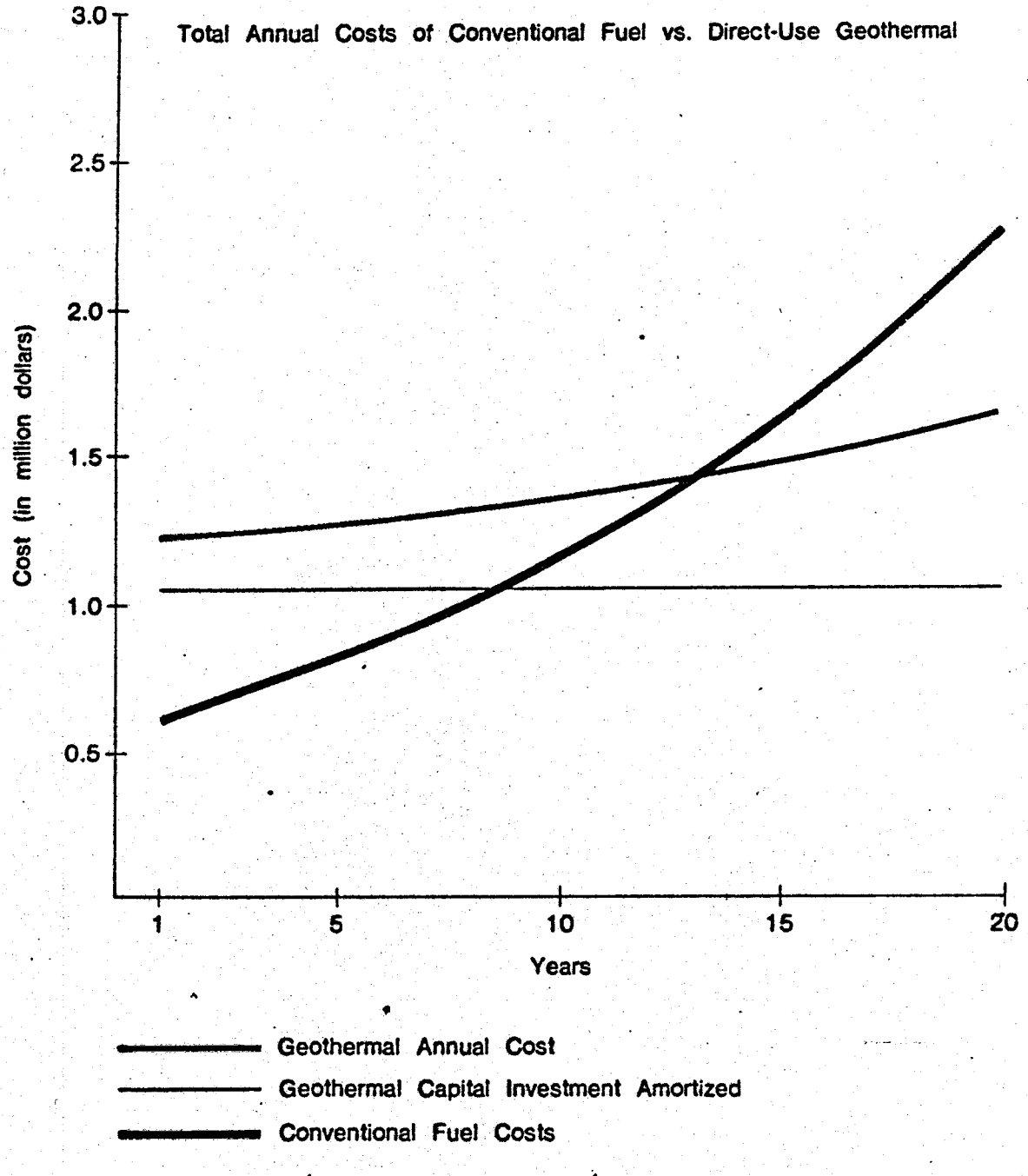
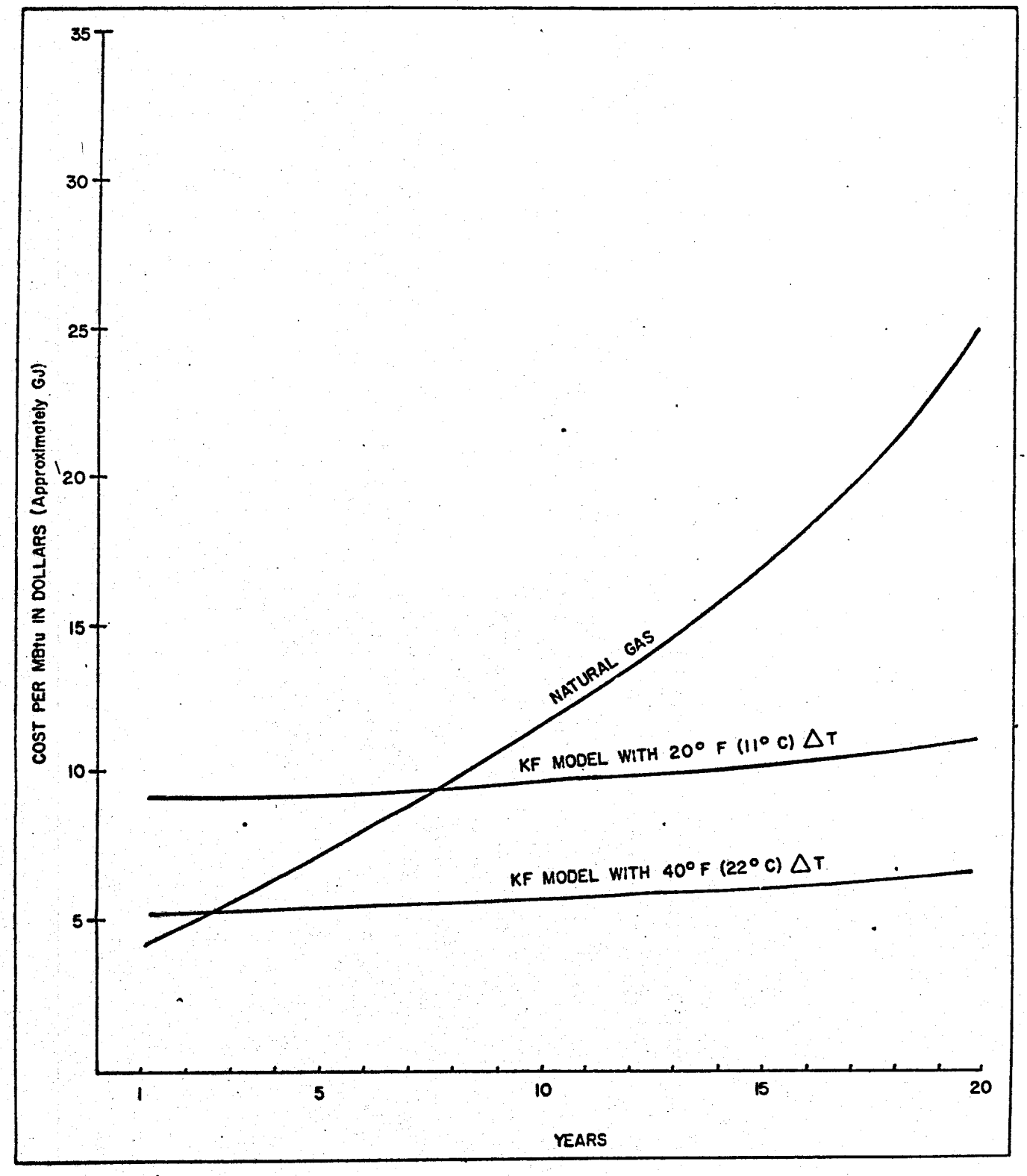


Diagram of the Klamath Falls hypothetical city heating system.

All graphs based on Klamath Falls model
Computer model must be modified for other cases

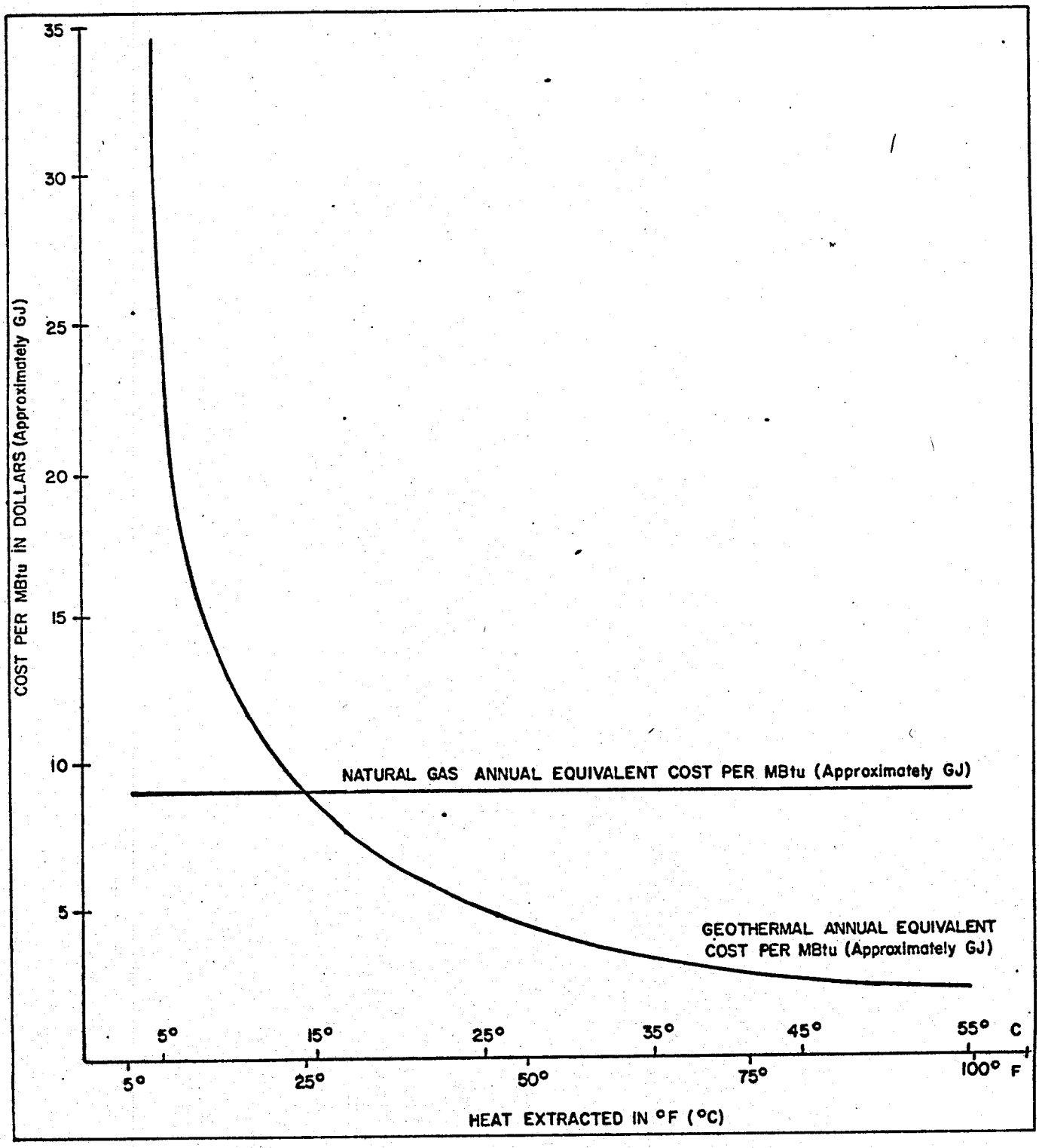


Use short term life cycle - 20-30 yrs.
Use conservative inflation estimates for conventional fuels

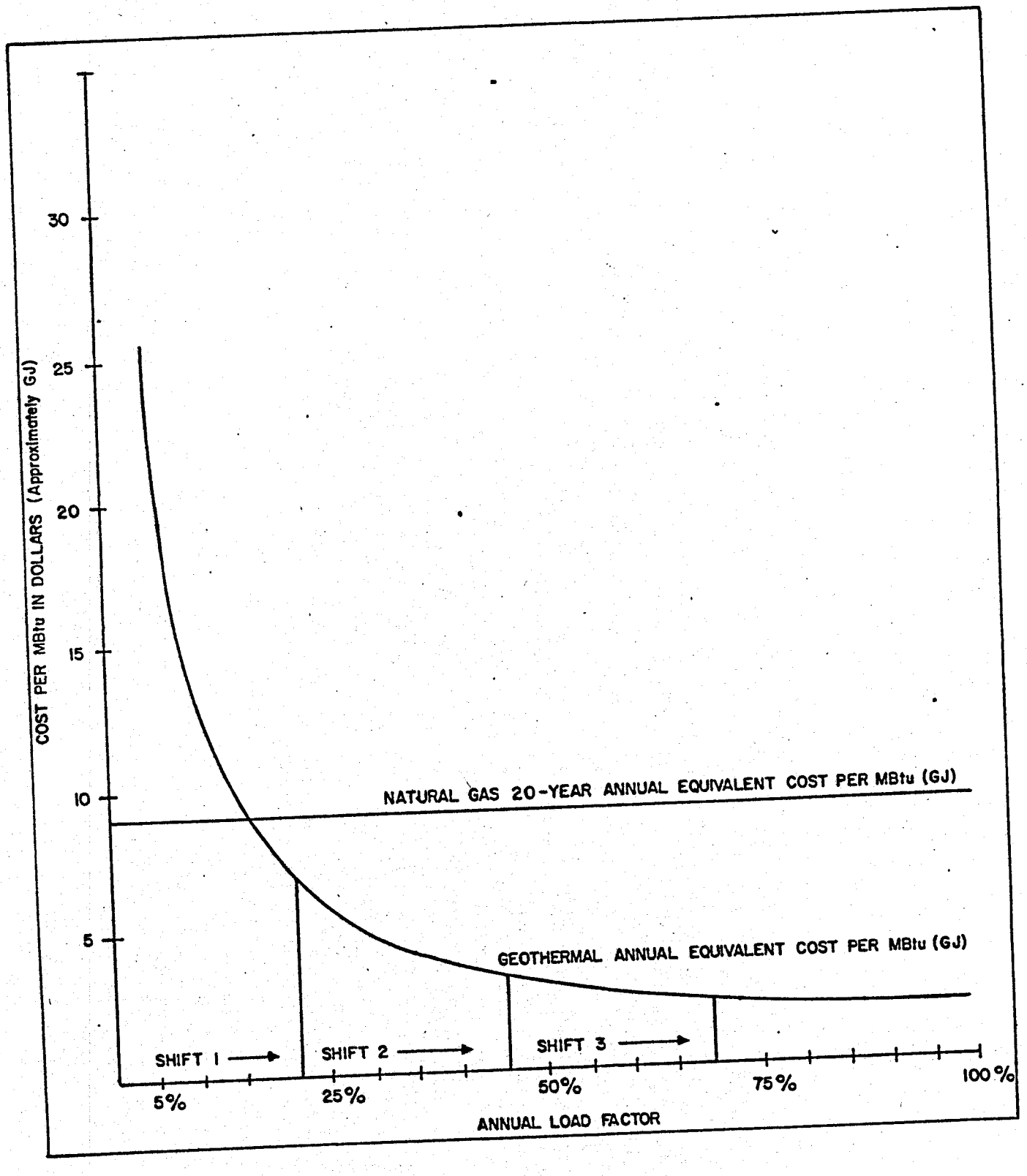


GRAPH 1. KF* Model cost per MBtu (GJ) as ΔT changes from 20°F (11°C) to 40°F (22°C) as compared to the forecast cost for natural gas inflating @ 12.2% through 1986 and at 8.5% thereafter.

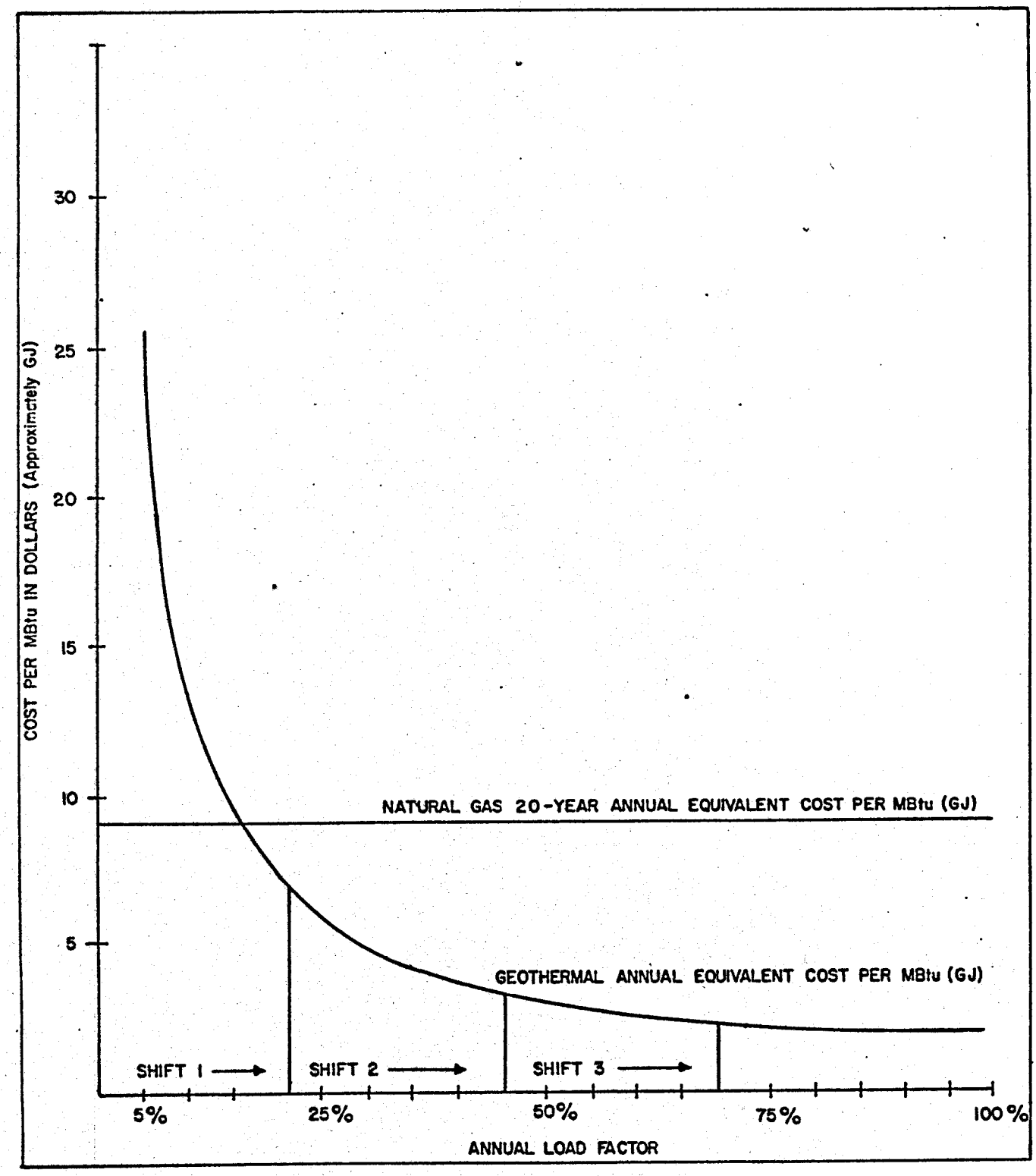
* Klamath Falls



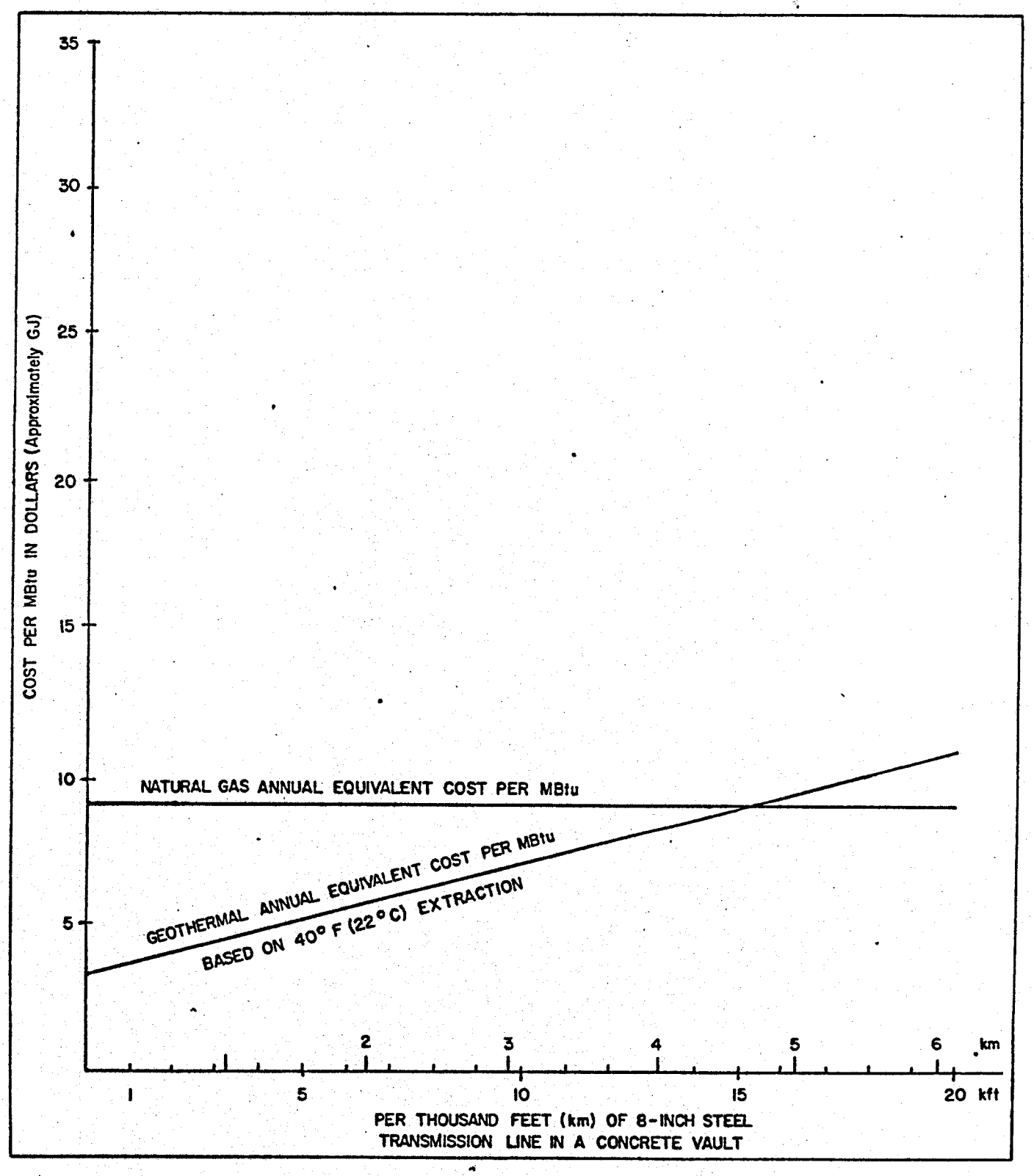
GRAPH 2. KF Model with a 25% annual heat load factor showing 20-year annual equivalent costs per MBtu at 15% as the heat extracted varies from 5-100°F (3-56°C).



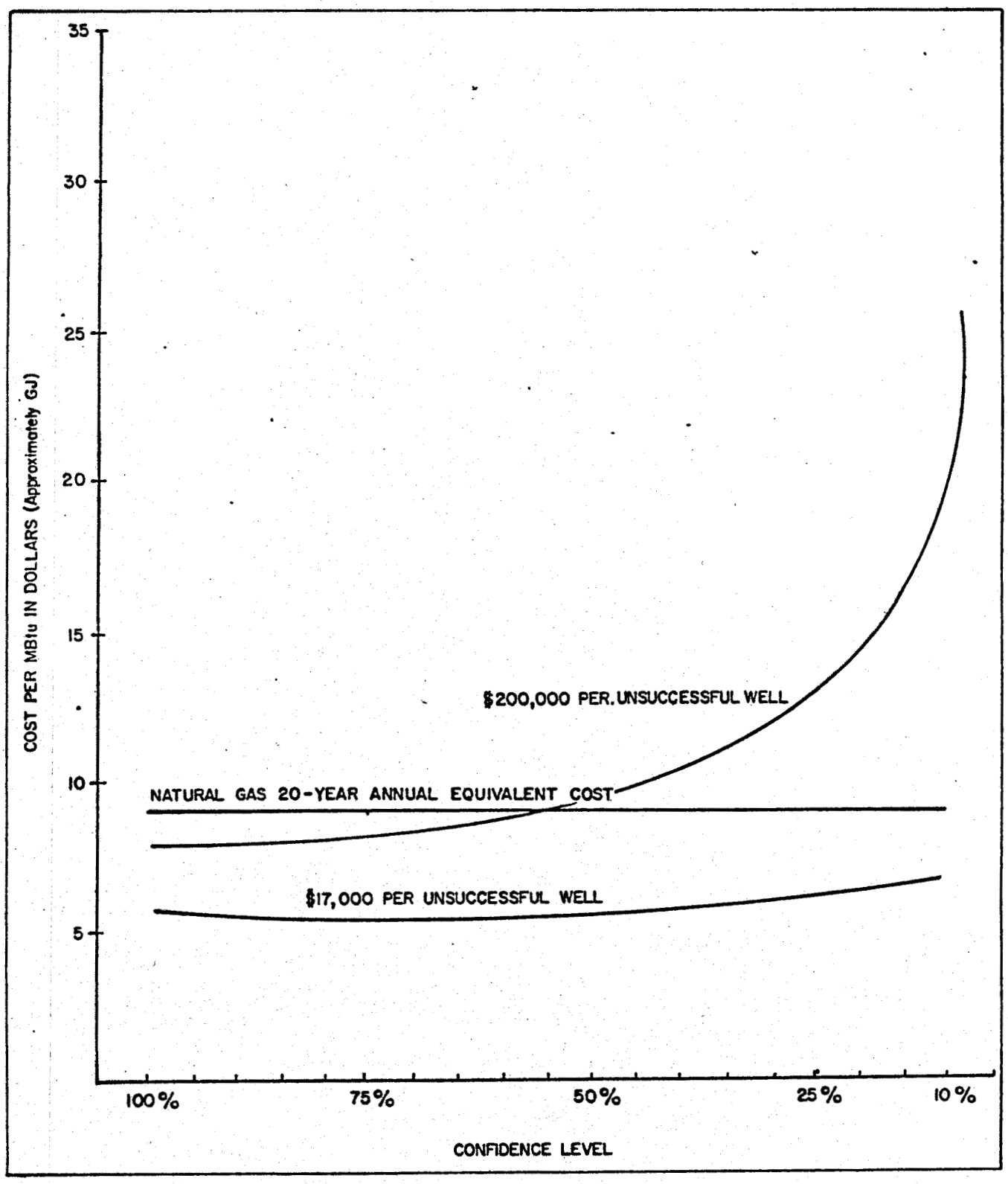
GRAPH 3. KF Model 20-year annual equivalent cost at 15% cost of capital as the annual load factor varies from 5% to 100%.



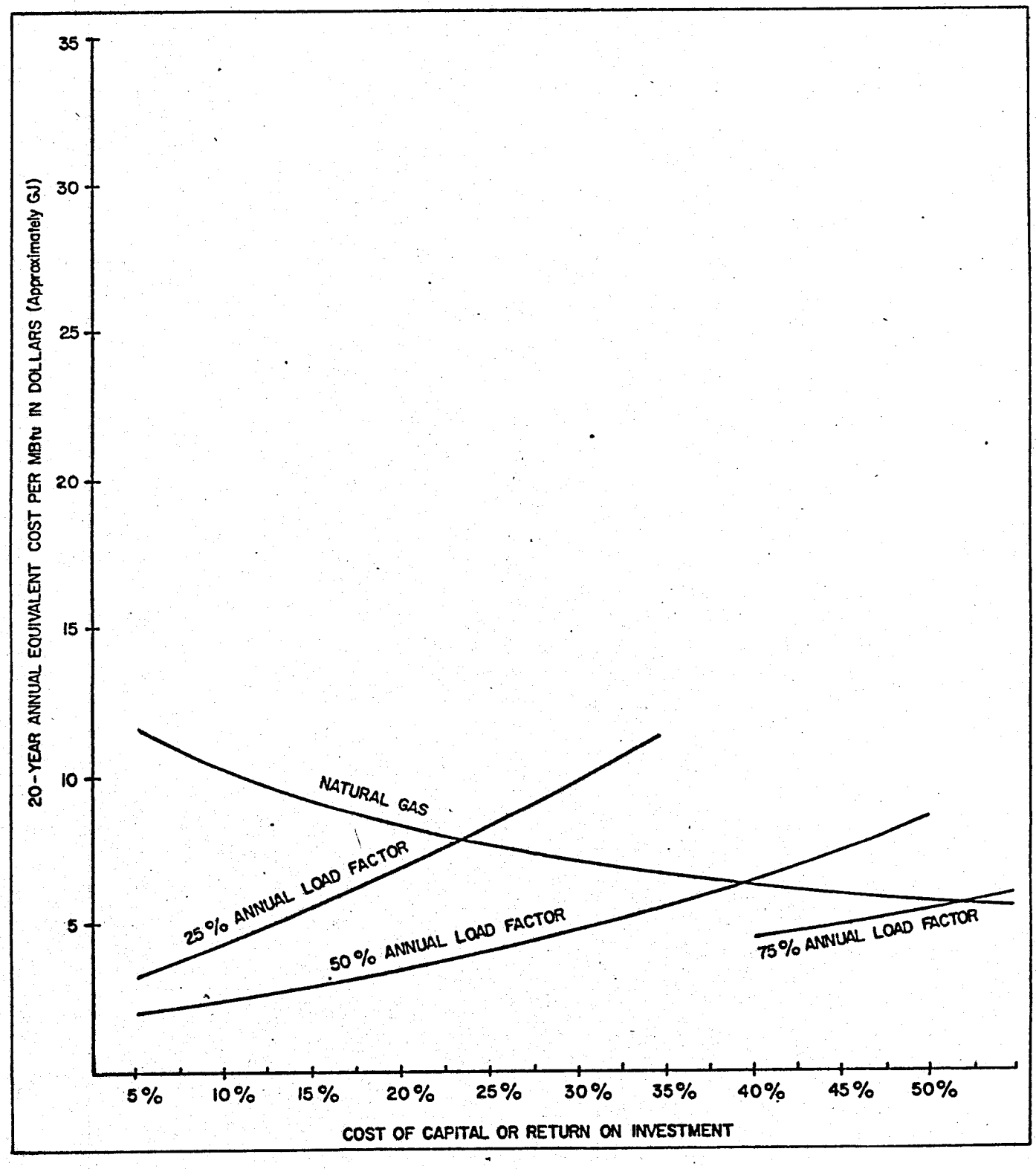
GRAPH 3. KF Model 20-year annual equivalent cost at 15% cost of capital as the annual load factor varies from 5% to 100%.



GRAPH 4. KF Model 20-year annual equivalent cost per MBtu (GJ) at 15% per thousand feet (km) of 8-inch (20 cm) transmission line in a concrete vault.

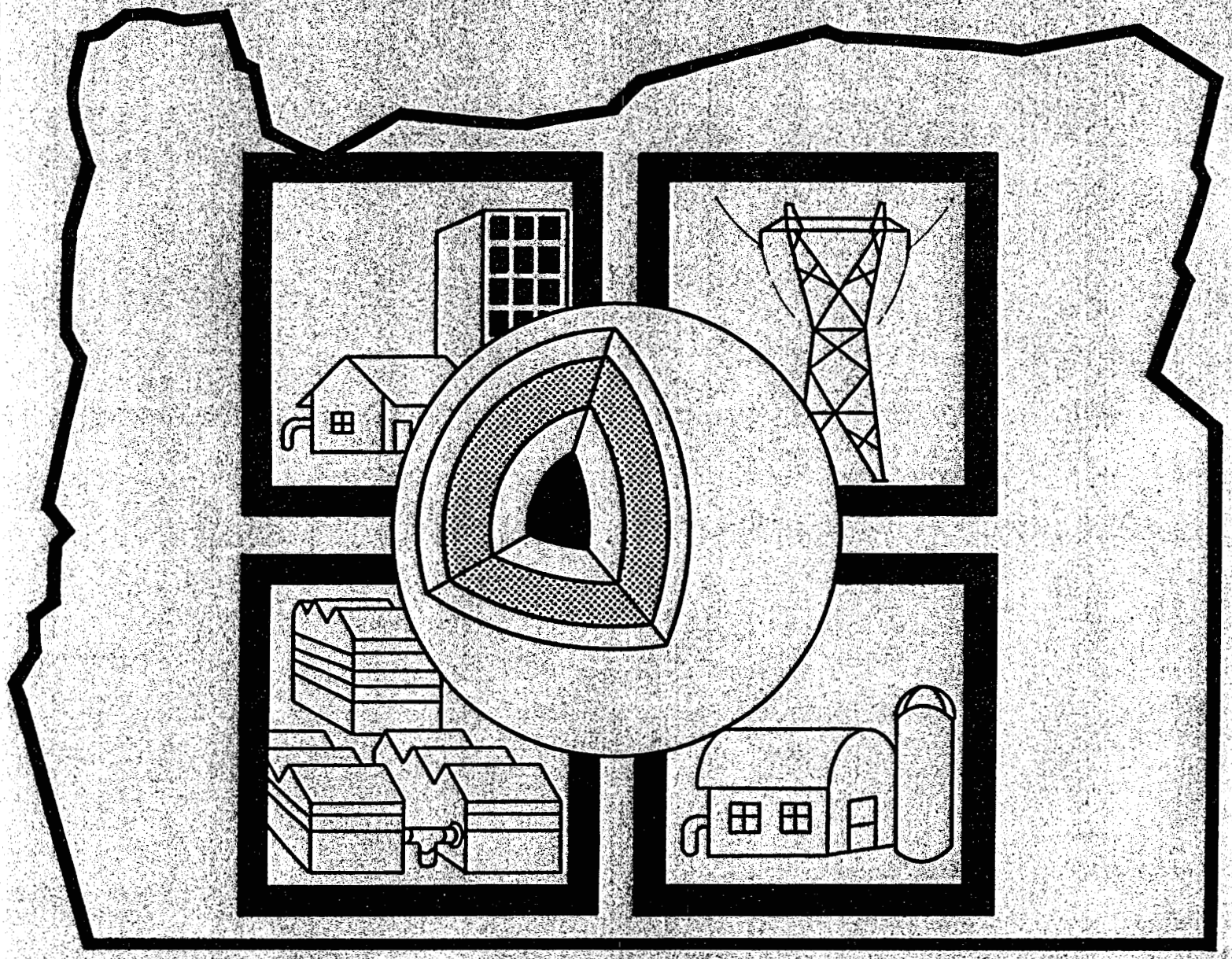


GRAPH 5. Confidence level vs. drilling costs.



GRAPH 6. Natural gas vs. cost of capital vs. annual load factors.

OREGON



GEOTHERMAL

TECHNICAL ASSISTANCE & FUNDING

with the developer through the TA program. State Departments of Geology, Water and Energy have cooperated with the TA program by providing limited services. Information, assistance incentives and funding sources from federal, regional and state sources is made available to the developer.

PROGRAM PROCEDURE

Developers interested in utilizing the TA program may contact program manager:

Gene Culver, Manager
Technical Assistance Program
Geo-Heat Center
Oregon Institute of Technology
Klamath Falls, OR 97601
(503) 882-6321 x267

Requests for assistance will be prioritized based upon proposed implementation dates. Existing fossil fuel users considering conversion to geothermal energy will be provided early assistance. Assistance generally involves the following steps:

1. Energy Audit - An energy audit determines the unnecessary consumption and loss of energy from a given facility. A developer may be asked to have an energy audit conducted so that an efficient design of a geothermal system can be completed by the TA program. Audits can be conducted by utilities and private firms. US DOE has a schools and hospitals program to provide the service. Recommendations from the audit will be incorporated into the geothermal design for the facility as well as identifying all energy use so that those which can be satisfied by geothermal can be identified.

2. Annual Fossil Fuel Consumption - Records are necessary on a monthly basis of the fossil fuel and electricity consumed by a facility for the purpose of comparing and checking energy demands to be calculated for the geothermal system.

3. Weather Data - Annual Degree Days, design temperature and correction factors are necessary for computing annual energy consumption and peak heating/cooling loads for space conditioning projects. This data is usually available from references.

4. Facility Design Details (Existing) - Existing drawings of facility are necessary for heat loss calculations and retrofit of mechanical equipment to geothermal. Ratings of heat production equipment is also desirable.

5. Peak Heating Load - Peak heating load is calculated from thirty-one day January average, degree day method and heat loss determinations. Peak load is necessary for the conceptual design.

6. Geothermal Conceptual Design - A conceptual design of the geothermal system (direct thermal and/or heat pump) is provided the developer based on peak heating load and heat production (resource temperature and flow). This results in a schematic and/or flow diagram which includes components such as production and recharge wells, and the sizing of pumps, pipelines, heat exchangers, etc.

7. Capital Investment - Components, installation, operating and maintenance costs are determined based on item 6 on the preceding page. Larger projects will be provided a capital investment schedule.

8. Economic Analysis - Energy savings between present fossil fuel and geothermal system will be determined as well as the income from savings to payroff principal (bonds) plus interest for the life of the project.

Site visits are made to obtain the necessary project data. A final report is presented to the developer with an explanation of the results and possible follow up contacts to determine how the project is progressing.

PROGRAM UTILIZATION

During the past year 61 projects and 316 information requests have been processed through the technical assistance program. A project being defined as a request for assistance that requires considerable effort, more than one or two days.

If all projects were carried to completion, the resulting geothermal energy on line would be approximately equivalent to 4,457,000 gal. of fuel oil saved per year. We are fairly certain that all will not be completed, in fact some are not economically justifiable and should not be completed.

Representative projects in Oregon receiving assistance during the past year include:

Site	Use	Resource Temp.
1. Government Camp	Space & water heat	70°F
2. Klamath Falls	12 home district	190°F
3. Klamath Falls	Apartments	150°F
4. Klamath Falls	Airport	?
5. Klamath Falls	120 home HUD project	220°F
6. Klamath Falls	Aquaculture	190°F
7. Klamath Falls	Sludge heating	170°F
8. Klamath Falls	County Shops	118°F
9. Klamath Falls	Alcohol Rehabilitation Ctr	80°F
10. LaGrande	Hospital	62°F
11. LaGrande	Alcohol Plant	180°F
12. Lakeview	Alcohol Plant	140°F

13. Lakeview	Aquaculture	?
14. Lakeview	City Pool	?
15. Oakridge	District Heating	160°F
16. Pendleton	College, space heat	65°F
17. Vale	District Heat	220°F
18. Vale	Mushroom	220°F
19. Vale	Alcohol Plant	150°F

During the past year, of the 61 projects, space and domestic water heating involved 38 projects, agriculture/aquaculture 3, and process heating 10 projects.

GEOTHERMAL

FUNDING OPPORTUNITIES

A. FEDERAL PROGRAMS

1. U.S. Department of Energy

a. User-Coupled Drilling Program: Cost-sharing for exploration and confirmation drilling and testing; minimum DOE cost share 20%, maximum 90%; solicitations tentatively scheduled every 9-12 months.

Contact: User-Coupled Drilling Program
USDOE
550 2nd Street
Idaho Falls, Idaho 83401
208-526-1669

b. Institutional Buildings Program: Cost-sharing for schools, hospitals, local governments, and public care facilities, to conduct conservation studies and implement capital improvement projects.

Contact: Utah Energy Office
231 E. 400 South
Salt Lake City, UT 84111
(801) 533-5424

c. Appropriate Technology Grant Program: Small grants (maximum $50,000) for energy conservation and renewable resource development; available to individuals, businesses, and local governments; next cycle, January-May, 1981.

Contact: Utah Energy Office
231 E. 400 South
Salt Lake City, UT 84111
(801) 533-5424

d. Geothermal Loan Guarantee Program: Offers loan guarantees for up to 75% of project costs.

Contact: Geothermal Loan Guarantee Program
USDOE
1333 Broadway
Oakland, California 97612
415-273-7151

e. Program Solicitations: Intermittent solicitations for research and development (PRDA's), demonstration (PON's), and other geothermal activities.

Contact: USDOE
1333 Broadway
Oakland, California 97612
415-273-7151

f. Unsolicited Proposals: USDOE considers unsolicited proposals for certain program needs.

Contact: Division of Geothermal Resource Management
USDOE
12th and Pennsylvania N.W.
Washington, D.C. 20461
202-633-8106

OR

Geothermal Officer
USDOE, Room 1910
915 Second Avenue
Seattle, Washington 98174
206-442-2820

g. Synthetic Fuels: Several programs with geothermal applicability.

Contact: USDOE Headquarters

2. U.S. Department of Housing & Urban Development

a. USDOE/HUD District Heating Initiative: HUD sponsored, four-phase promotion of district heating. Phases include: feasibility studies ($1 million available Oct. 15), conceptual design ($2.8 million available Jan.), final design, and construction.

Contact: Community Planning & Development
HUD
125 S. State
Salt Lake City, UT 84111
524-5240

b. Community Development Block Grants: 100% grants for housing and public facility improvements; preapplication deadline Nov. 17.

Contact: Community Planning & Development
HUD
520 S.W. 6th
Portland, Oregon
603-221-2601

c. Urban Development Action Grants: Cost-shared public-private projects to stimulate employment in and revitalization of blighted areas; city must be ruled eligible by HUD criteria.

Contact: HUD
125 S. State
Salt Lake City, UT 84111
524-5240
503-..

& Development

3. U.S. Economic Development Administration

a. Public Works & Development Facilities: Cost-shared grants (50-80% federal) for public and non-profit organizations for industrial and related facilities.

Contact: Economic Development Administration
125 S. State
Salt Lake City, UT 84111
(801) 524-5119

b. Business Development Loans: Direct loans and guarantees for employment or facility expansion.

Contact: Economic Development Administration
125 S. State
Salt Lake City, UT 84111
(801) 524-5119

c. Local Public Works (LPW) Round 3: ?

Contact: Economic Development Administration
125 S. State
Salt Lake City, UT 84111
(801) 524-5119

4. U.S. Farmers Home Administration

a. Community Facility Loans: Insured loans for cities with less than 10,000 population for essential community facilities.

Contact: Farmers Home Administration
125 S. State
Salt Lake City, UT 84111
(801) 524-5027

b. Business & Industrial Development Grants & Loans: Assistance for economic development projects in rural areas.

Contact: Farmers Home Administration
125 S. State
Salt Lake City, UT 84111
(801) 524-5027

~~5. Sp. Pub. program~~

B. REGIONAL PROGRAMS

1. Pacific Northwest Regional Commission

Several geothermal studies and demonstrations previously funded.

Contact: PNRC
Oregon Program Coordinator
160 State Capitol
Salem, Oregon 97310
503-378-3457

C. STATE PROGRAMS

1. Oregon Department of Energy

a. Small Grants: Several small geothermal feasibility studies have previously been funded.

Contact: Geothermal Specialist
ODOE
Labor & Industries Building
Salem, Oregon 97310
503-378-4040

b. Energy Loan Program: Low-interest loans for individuals, small businesses, and public agencies for alternate energy projects producing heat, electricity, or substitute fuel; available January, 1981.

Contact: Energy Loan Program
ODOE
Labor & Industries Building
Salem, Oregon 97310
503-378-4040

2. Oregon Department of Economic Development

a. Industrial Revenue Development Bonds: Available for financing the construction of geothermal industrial applications.

Contact: Industrial Development Section
Dept. of Economic Development
Executive Building
Salem, Oregon 97310
503-373-1200

EXISTING

GEOTHERMAL FINANCIAL

INCENTIVES

A. Federal

1. Residential income tax credit for geothermal installation; 40% of geothermal cost up to a maximum credit of $4,000.

2. Businesses are eligible for a 15% energy investment tax credit in addition to the regular 10% investment credit.

3. Intangible drilling costs and depletion allowance are allowable for private geothermal projects.

B. STATE OF OREGON

1. Personal income tax credit of 25 percent of the cost of an individual residential geothermal system, up to a maximum $1,000 credit per dwelling.

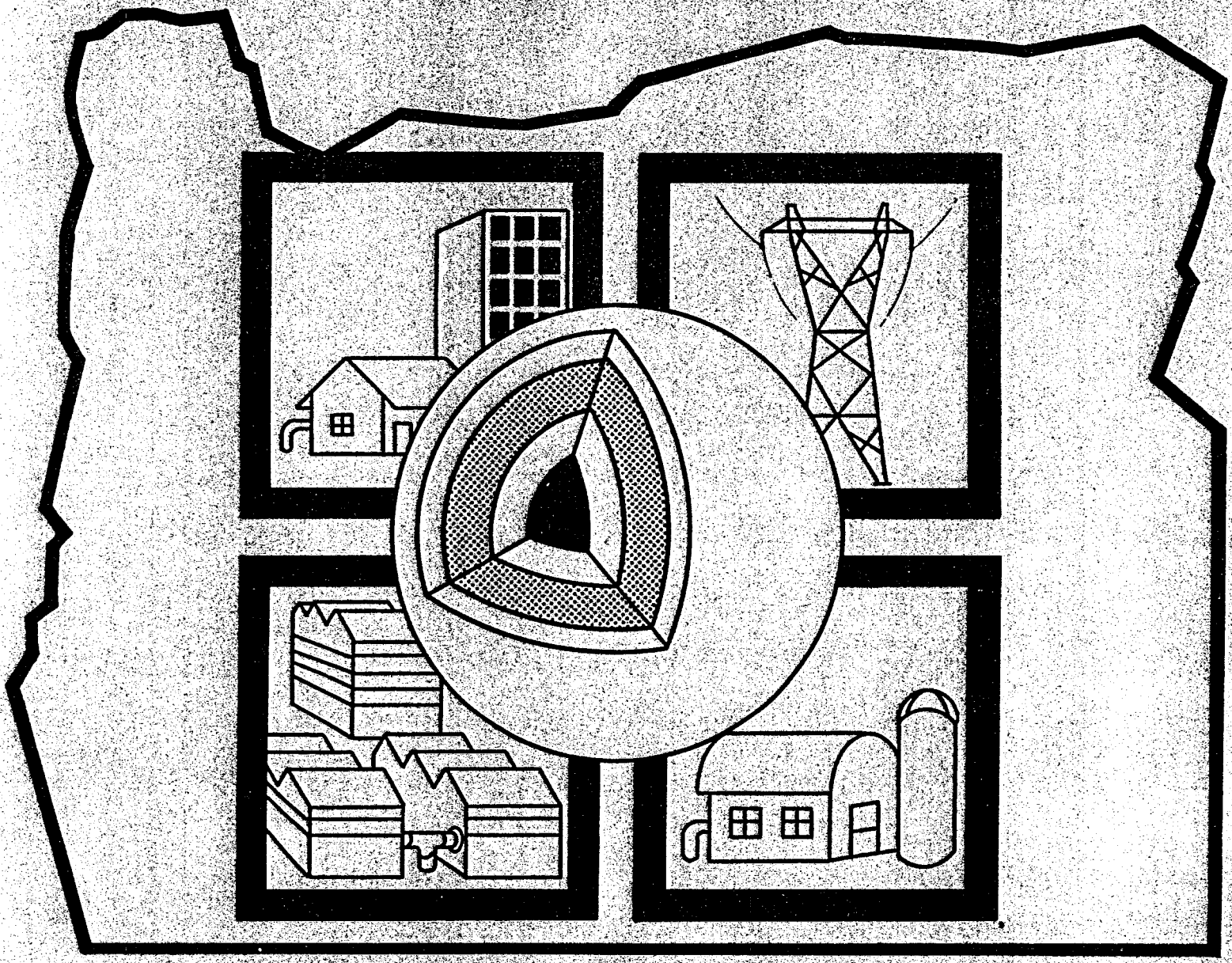
2. Personal income tax credit of 25 percent of the cost of connecting a residence to a geothermal district heating service, up to a maximum $1,000 credit per dwelling.

3. Business income tax credit of 35 percent of the cost of an individual business geothermal system, claimed over a five-year period.

!! 4. The enhanced value of property due to the installation of geothermal systems is specifically exempted from ad valorem taxation. Great idea!

5. The state veterans home loan program will loan up to $3,000 over the maximum otherwise allowable for the installation of a residential geothermal system.

OREGON



GEOTHERMAL

CASE STUDIES

Published by Idaho Dept. of Energy

KETCHUM, IDAHO
SITE SPECIFIC DEVELOPMENT ANALYSIS
TABLE OF CONTENTS

KLAMATH FALLS GEOTHERMAL DISTRICT HEATING

The following is a summary of the conceptual design report and the proposed geothermal heating district project awarded to the City of Klamath Falls under PON EG-77-N-03-1553 to the City of Klamath Falls, Oregon to design, construct and initiate operation of a geothermal space heating district. The district utilization project is for a City owned and operated system serving 14 city, county, state and federal office buildings. The project is essentially broken down into three phases which include establishment of wells, construction of a distribution line and the retrofiting of the existing buildings.

The production area to produce the geothermal waters for the heating of the district is to be in the vicinity of the Old Fort Road area which is further described in the conceptual design report. The production area is located within the second largest KGRA, as reported by the U. S. Geological Survey. The project will involve two production wells of approximately 1,000' deep with an estimated production of 500 gallons per minute each. The anticipated temperature from the production wells is 220°F and the required flow for the 14 buildings is 768 gallons per minute. The estimated peak load for the 14 buildings is 15.326×10^6 BTU per hour.

Each production well will be outfitted with a 75 h.p. turbine pump with variable speed drive. Each well and pump will be enclosed by a 10' x 10' well head building. The geothermal waters will be transported 4,060' to the vicinity of the County Museum and the City Fire Station. The geothermal waters will be transported by single 8" diameter steel pipe with urethane wrap insulation and placed in a concrete tunnel. The tunnel will be 58" x 38". The tunnel will be installed in 10' sections with removable tops for easy maintenance and future expansion. The tunnel will be placed in existing public rights-of-way and, wherever possible, will become a part of the sidewalk surface that currently exists.

At the end of the geothermal line a centralized heat exchanger building 30' x 40' will be used to house two plate heat exchangers. The two plate heat exchangers will then transfer the heat from the geothermal line to a closed loop domestic water line. In addition to the two heat exchangers, a heat exchange building will include two vertical turbine circulation pumps of 50 h.p. capable of pumping 400 gallons per minute each. To handle surges and expansions, a 1,000 gallon pressure and surge tank will be housed at the central heat exchange building. A telemetry system controlling pumping requirements, heating requirements and the appropriate flow for those requirements will be the basic control system which also will be housed in the central heat exchange building.

After the geothermal waters have circulated through the two steel plate exchangers, the water will be reinjected into an existing well in the vicinity of the County Museum. The centrifugal injection pump of 20 h.p. will be installed for injection.

The closed loop domestic pipe will supply the fourteen buildings at an estimated temperature of 200°F. The line will consist of 8", 6" and 3" RFP pipe which will be directly buried along the pipe route.

The secondary line will then provide service to the U.S. Post Office, State Employment Office, State Welfare Office, City Hall, City Hall Annex, City Jail, County Courthouse, Veterans Memorial Building, County Jail, County Courthouse Annex, County Library, County Courthouse Extension, County Museum and City Fire Station.

The capital cost of the intended system is as follows:

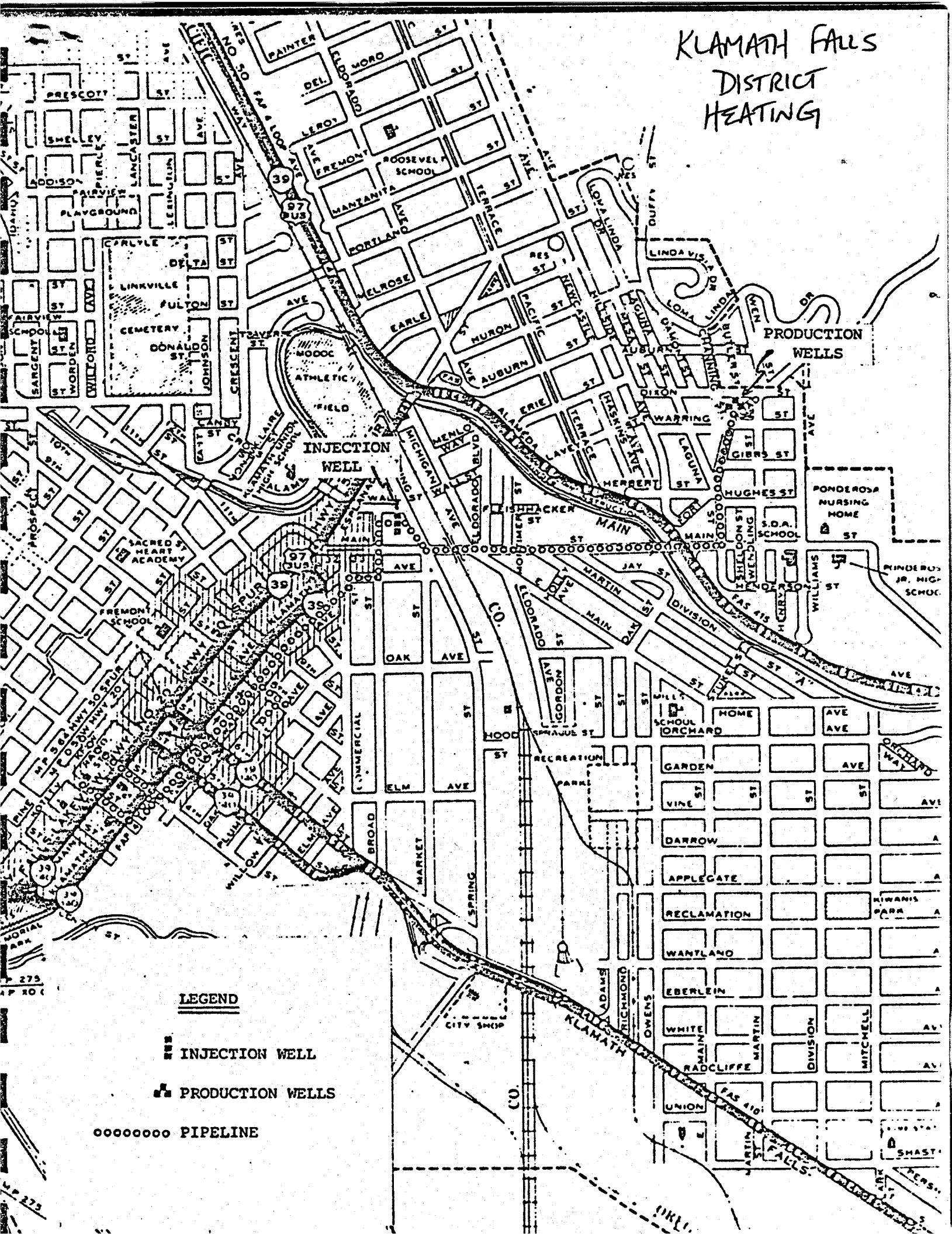
A.	Wells and Well Head Equipment	$ 169,772
B.	Pipe Lines	835,293
C.	Heat Exchanger Facilities	197,506
	Subtotal	$ 1,242,571
D.	Engineering and Inflation	197,429
	Total	$ 1,400,000

The estimated equivalent annual cost of capital for this system, based on a 20-year life and 6.5% interest, with the inclusion of operation and maintenance costs, are $201,601. Using an expanded system heat load for 11 commercial blocks, the estimated cost of the geothermal energy is $0.29/therm through a 20-year period. The equivalent annual cost for natural gas over the same 20-year period is $662,291, which is based on Oregon Department of Energy projections. This amounts to an average annual cost of natural gas of $0.94/therm or 335% higher than geothermal.

The preceding is intended as a summary of the project and the various components of the project. Further detail of the individual components is found specified in the Commercial District Design Report dated February, 1979.

The project size and future plans for the Geothermal Heating District calls for expansion to both commercial and residential users. Such expansion, in all likelihood, shall be predicated on voter approval for bond issues for constructing funding.

KLAMATH FALLS DISTRICT HEATING



OAKRIDGE

ABSTRACT

Geological and geophysical data indicate that Oakridge is underlain by geothermal waters. The strongest evidence is from the geothermal gradient, the increase of temperature with depth, in a 400' well on the south edge of the City. Although this well shows signs of disturbance by ground water, the geothermal gradient appears to be similar to the gradient from a well near McCredie Hot Springs seven miles to the east. Additional evidence is a salt spring, just south of the City, that may represent a fossil geothermal system that has become sealed and is no longer flowing hot water. A third line of direct evidence is the presence of a warm spring about three miles southeast of the City that is now covered by Hills Creek Reservoir. Indirect geophysical evidence is a high gravity gradient from west to east near Oakridge. This gradient relates closely to the region of increasing geothermal gradient and heat flow of the Cascade Geothermal Anomaly. Indications of intersection of regional fault patterns could provide the subsurface fracturing and permeability necessary for a geothermal reservoir. The results of this study indicate that water sufficiently hot to be useful can be located by drilling to depths of three to four thousand feet at Oakridge. Three sites are proposed for shallow geothermal gradient holes to test the proposed model.

Environmental effects of the proposed geothermal exploration, development and production plan are discussed using two models; one, drilling at the nearest known source, Kitson Hot Springs and building a pipeline to Oakridge, and two, drilling and developing a supply system in or adjacent to the City. Detrimental environmental effects of drilling and developing a supply system and pipeline from Kitson Hot Springs are largely related to construction problems in the narrow valley where the Hot Springs are located and the esthetics of an above-ground transmission line along the Hills Creek road. Development in or adjacent to the City presents more favorable terrain. Here, the detrimental effects would largely be related to accidents in the form of spills or casing failures and would therefore be of short duration. The most significant environmental benefit would be reduction of the potential air pollution in Oakridge caused by increased use of fossil fuels and from wood heating. The issues, impacts and benefits are present for discussion by the Community.

Six development scenarios are considered with a pipeline from Kitson Hot Springs or local source delivery from wells in Oakridge to three groups of energy users. Option I, the smallest consisting of a cluster of public-owned/leased buildings near the center and eastern edge of Oakridge, appears to be economically viable with local source development but not from a pipeline supply. Option II, including Option I and additionally some use at the Pope and Talbot Mill and the Oregon State Trout Hatchery, appears to show the most rapid pay-off with local source development and may be sufficiently attractive to support the cost of the pipeline. Option III includes I and II and would take over several existing commercial, industrial and residential heating loads at Willamette City and the west side of Oakridge. This option requires much more capital but appears viable either by pipeline supply or from a local source of hot water. Load estimates and costs for the system are presented and discussed.

A review and discussion of potential industries that could make use of geothermal waters is presented. A listing of significant factors including importance of low grade energy in selecting a site, environmental acceptability and several other criterion is given. A discussion of the factors and reasoning in the development of the listing is given.

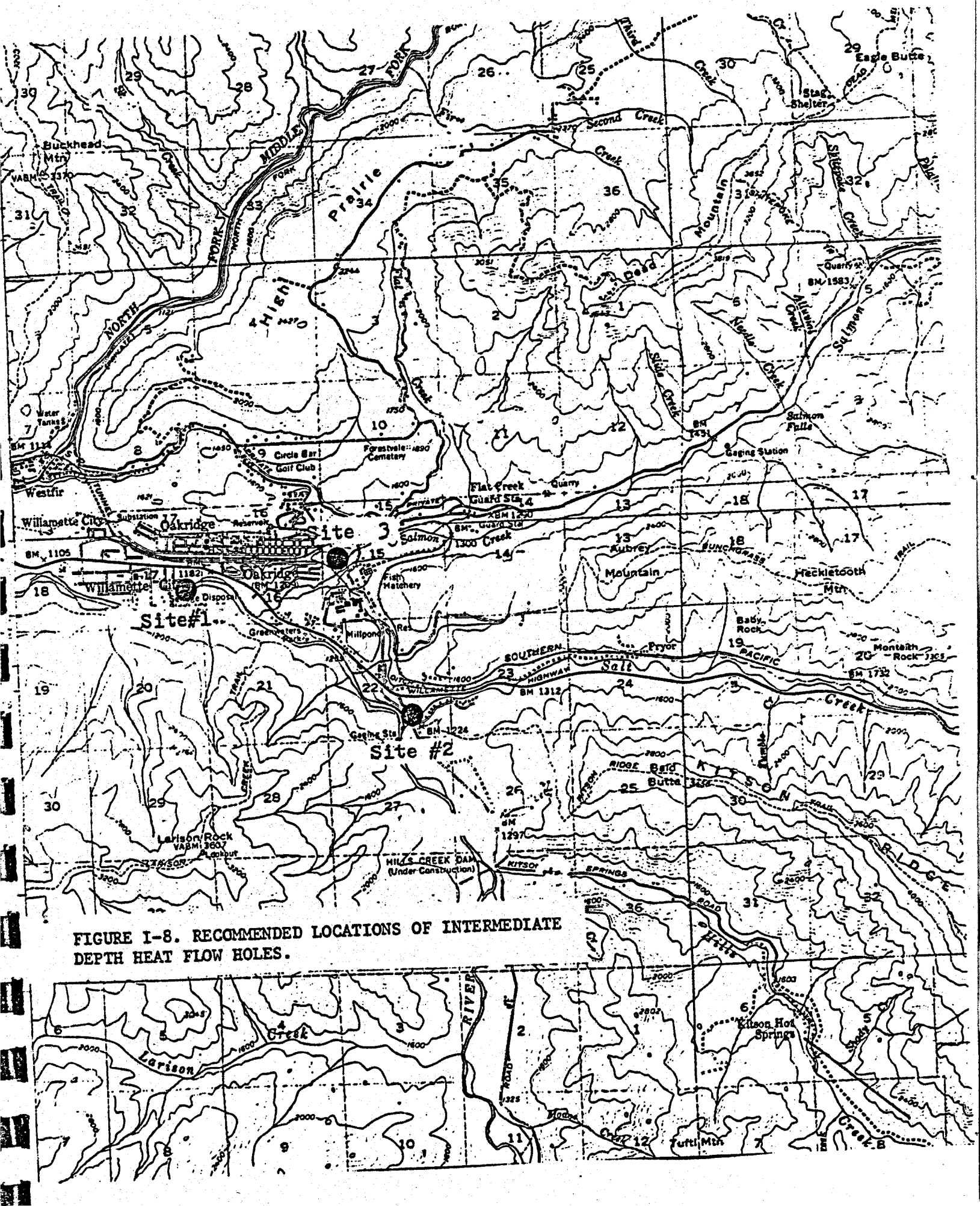


FIGURE I-8. RECOMMENDED LOCATIONS OF INTERMEDIATE DEPTH HEAT FLOW HOLES.

GEOTHERMAL DIRECT HEAT APPLICATIONS
DEMONSTRATION PROJECTS
FUNDED IN PART BY THE U.S. DEPT. OF ENERGY

District Heating/Space Heating

Space Heating - Memorial Hospital, Marlin, Texas

This project will provide augmented space and water heating for the Torbett-Hutchings-Smith Memorial Hospital in Marlin, Texas. Geothermal fluids will be pumped from a known hot water reservoir, using a new well to be drilled as part of this project. The government will fund approximately 67% of the total project cost of $660,000.

Heating Douglas High Schools; Box Elder, S.D.

In this project, the Douglas School complex in the community of Box Elder, South Dakota will be heated with hot water from a well drilled into the Madison Aquifer. As a cost-shared endeavor, the government's share of the total project cost of $320,000 is approximately 70%.

Heating Phillips Schools, Haakon, S.D.

In the project, at the Haakon School District, Haakon, SD, school buildings will be heated with geothermal water from a well to be drilled into the Madison Aquifer. This project provides government funds on a cost-shared basis for design, construction and start of operations for the complete system. The amount budgeted will provide for approximately 80% of the total project cost of $500,000.

Heating St. Mary's Hospital, Pierre, S.D.

St. Mary's Hospital in Pierre, SD will have its heating system augmented with a system drawing hot water from the Madison Aquifer. Extension of the system to a nearby commercial complex is anticipated. Of the total project cost of $470,000 over a two-year period, the government's share will be approximately 75%.

District Heating, Monroe, UT.

In the city of Monroe, UT, a district heating system will be built, based on the development of a known hydrothermal resource in the area. The project, which provides for production wells as well as for design and construction of the district heating system will be a joint effort with the government providing approximately 75% of the funds. Total project cost will be $1,300,000.

District Heating, Klamath Falls, OR.

This project provides for design and construction of an extensive geothermal space heating system in the central business district of Klamath Falls. OR. As a city-owned and operated system, it initially will serve 14 office buildings (city, county, State and Federal), with subsequent expansion to 115 private commercial buildings. The system will include, initially, one production well, one reinjection well, approximately 2 miles of transmission line, retrofitting equipment for all 14 government buildings, and appropriate control equipment. The government's share of the total project cost of $1 million will be approximately 75%.

Multiple Uses at Moana, Reno, NV.

This project involves retrofit of an apartment complex in Reno, Nevada with a geothermal space and water heating system, utilizing thermal waters in the Moana District, a known geothermal resource. Government funds will provide approximately 65 percent of the total project cost of $630,000.

Geothermal Distribution & Heating, Pagosa Springs, CO.

In this project, there will be an extensive geothermal heating system within the town of Pagosa Springs, Colorado. Designed to permit expansion of other businesses and homes beyond the town limits, this system provides hot water for space heating to 12 public buildings and schools, 25 private buildings and several homes. The Government's share amounts to approximately 75 percent of the total project cost of $960,000.

Direct Uses, Elko, NV

Under the ownership of a heat source company, geothermal fluid from the Elko, Nevada KGRA will be used to provide space, service water and process heating to several buildings within the city. The Government's share of the total project cost of $1,100,000 will be approximately 60 percent.

District Heating, Boise, ID.

The city of Boise, Idaho and the Boise Warm Springs Water District will develop a large scale space heating system using geothermal energy to demonstrate the technical, economic and organizational feasibility of using low temperature fluids in a multijurisdictional endeavor. DOE funds will pay for approximately 62 percent of the total project cost of $8,000,000.

Heating Warm Springs Hospital, Butte, MT.

In this project, managed by the Montana Energy and MHD Research and Development Institute, utilities at a hospital near Butte, Montana will be partially converted to use geothermal energy instead of natural gas. The project is a continuation of state-funded studies intended to determine the feasibility of converting to a geothermal resource, and to more fully define the resource on hospital property. It will involve drilling of geothermal and reinjection wells, design and modifications of the hospital hot water and space heating systems, including installation of geothermal heat exhangers and piping. The Government's share will be approximately 22 percent of the total project cost of $2,200,000.

Geothermal Heating - Navarro College, Corsicana, Texas

Utilizing a known geothermal resource, the contractor will retrofit two buildings; the college student union and the Navarro County Memorial Hospital, to augment the existing space and water heating requirements. Of a total project cost of $870,000, the government will provide approximately 75% of the funds.

District Heating, Susanville, CA.

The city will utilize the Susanville geothermal resource to provide space heating to 17 existing public buildings. A parallel effort will involve expansion of the city system and development of a commercial park. The government's share of the total project cost of $4,300,000 will be 45%.

YMCA Geothermal Space and Water Heating, Klamath Falls, CA.

A system will be designed and constructed to use geothermal fluids from a recently drilled well to provide space heating and hot water for a YMCA building. The existing fossil fuel system will remain as a back-up or booster system. The government will fund 75% of the total cost of $224,000.

Geothermal Core Field Experiment, El Centro, CA.

Geothermal resources from the Heber KGRA will be used to provide space cooling and heating, and domestic hot water to the community center at El Centro. It is intended that this project serve as the core for a future district heating and cooling system for the city. The government proposes to fund 70% of the project $2,650,000 cost.

Process Heat/Agriculture/Aquaculture/Food Processing

Direct Utilization - Agribusiness, Rapid City, S.D.

Near Rapid City, SD, a low temperature geothermal resource will be used to supply heat to ranch buildings, and will also be used to dry grain and to provide warm stock water for ranch use. Over the 3 years of the project duration, the government's share of the total project cost of $230,000 will be approximately 75%.

Food Processing - Ore-Ida , Boise, ID.

In this project, Ore-Ida Foods, Inc., Boise, ID, will use a geothermal energy source to retrofit an existing fossil fuel system for food processing and space heating in their existing potato processing plant in Ontario, OR. Wells will be drilled to supply fluids for a system to be designed and constructed, with the government's share of this joint project to be approximately 46% of total project cost of $5,200,000.

Multiple and Industrial Uses, Madison County, ID. Rexburg well

In a joint effort by Madison County, Idaho and Rogers Food, Inc., this project provides for developing the use of geothermal energy for municipal space heating and industrial food processing. The Government's share in this project amounts to approximately 50 percent of the total project cost of $3,300,000.

Direct Uses in a Floral Greenhouse, Salt Lake City, UT.

In this project 6 acres of greenhouses will be converted from oil and gas heating to a geothermal system. The Government will provide approximately 52 percent of the total project cost of $880,000.

Direct Applications at Kelley Hot Springs, CA.

Utilizing two wells at Kelley Hot Springs, the Geothermal Power Corp. will demonstrate a geothermal direct energy application to a livestock feed production system and hog feed lot operation. The government will fund 30% of the total cost of $6,000,000.

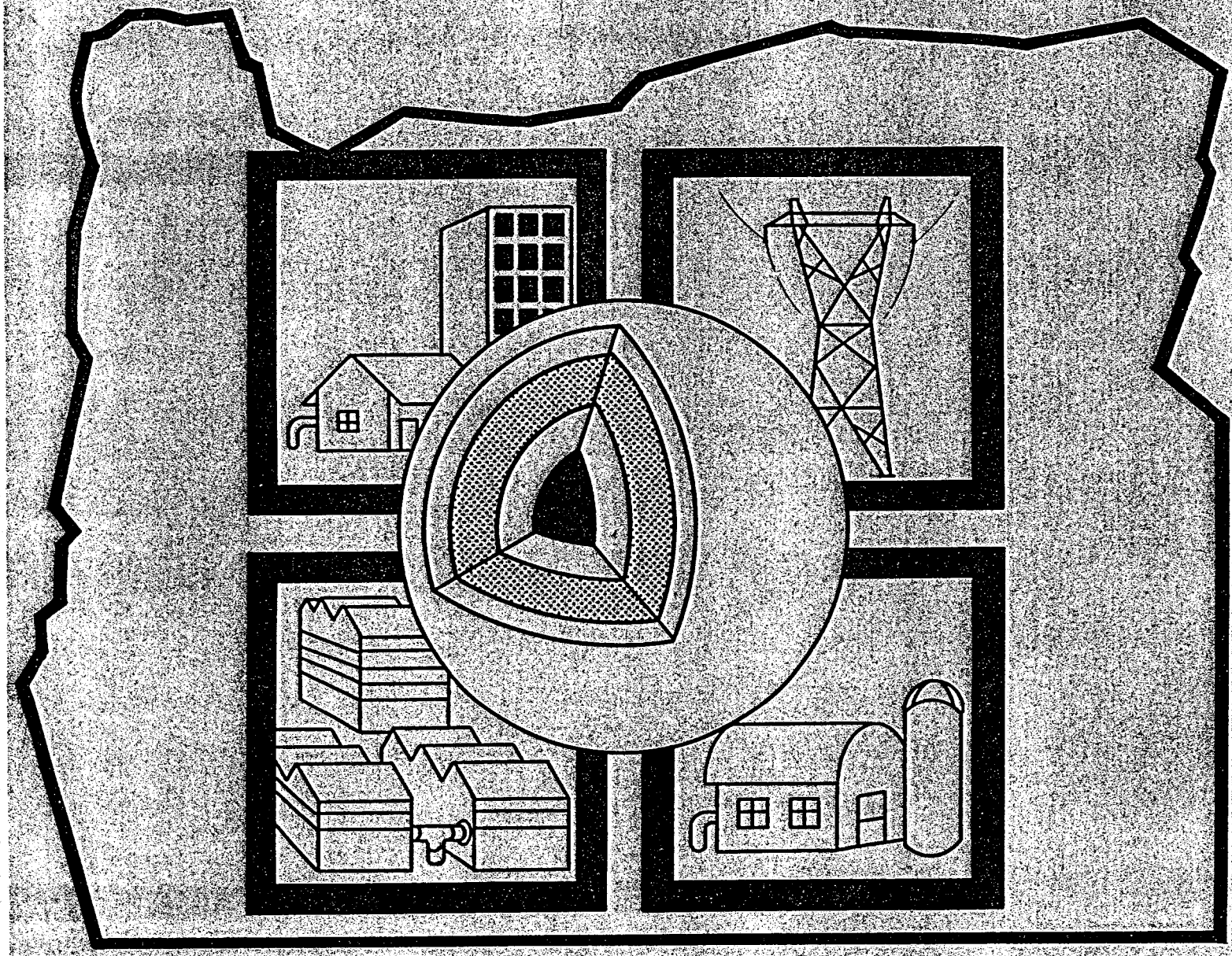
Aquafarm Prawn Raising, Mecca, CA.

A commercial fish farmer will expand an existing geothermally supplied system to raise giant Malaysian prawns. The government will provide 33% of the total project cost of $1,090,000.

Holly Sugar Geothermal Project, Brawley, CA.

This project involves the design, installation and operation of a geothermal energy system to be used directly for process heat at the Holly Sugar Refinery. The government proposes to fund 22% of the total project cost of $18,000,000.

OREGON



GEOTHERMAL

ENVIRONMENTAL & PLANNING ISSUES

Geothermal Environmental Problems

Peter Paquet, Oregon Department of Energy

ECOSYSTEMS

I. Geothermal Development and Ecosystem Resources

A. Definition of an ecosystem: a complex of living things with their non-living environment (soil, water, climate) linked through energy flow and material cycling.

B. Geothermal renewable resource often occur in areas where major land uses depend on ecosystem productivity.

1. Agriculture
2. Timber production
3. Livestock grazing
4. Fish and wildlife
5. Watershed
6. Outdoor recreation

C. A major challenge is the development of geothermal energy while protecting these existing resources and land uses.

II. Potential Impacts of Geothermal Development on Ecosystem Resources

A. Impacts will be very site-specific and will depend on:

1. Ecosystem resources of the project area.
2. Nature of the geothermal resource.
3. Type of utilization technology or geothermal energy application.

B. Primary impacts of geothermal development operations
   1. Known effects
      a. Loss of wildlife habitat and vegetation cover.
      b. Erosion and stream siltation.
      c. Destruction of stream biota from accidental spills.
      d. Vegetation stress from cooling tower drift.
   2. Potential impacts
      a. Reduction in wildlife abundance and diversity in adjacent habitat.
      b. Accumulation of heavy metals and other hazardous materials in aquatic and terrestrial food chains.

C. Secondary impacts of geothermal development operations.
   1. Geothermal development may have implications for public or private use of ecosystem resources.
      a. Restriction of access because of considerations of public safety or the security of geothermal facilities.
      b. Making unauthorized access easier over new roadways may lead to
         i. Increased off-road vehicle impacts.
         ii. Increased hazard of wildfire.
         iii. Increased illegal hunting and harassment of wildlife.
   2. Geothermal development may lead to growth in local population centers, with increased pressure on ecosystem resources.

III. Baseline Studies for Geothermal Development Projects

A. The first step in planning is careful collection of baseline data regarding existing ecosystem resources and land uses.
   1. Soils
   2. Hydrologic features
   3. Natural vegetation and crops
   4. Wildlife

d. Reproduction areas
   i. Fish spawning and nursery grounds.
   ii. Waterfowl and raptor breeding areas.
   iii. Big game fawning and kidding areas.

e. Wintering habitat
   i. Waterfowl.
   ii. Raptors.
   iii. Big game.

IV. Planning for Geothermal Development

A. The objective must be to minimize adverse impacts from the outset.

B. In siting geothermal facilities, certain principles should be observed.
   1. Identify and avoid critical or sensitive ecosystem resources.
   2. Minimize land requirements.
   3. Leave large blocks of intact habitat.

C. A number of impact control measures should be implemented
   1. Erosion control through proper engineering practices.
   2. Revegetation of disturbed areas.
   3. Control of excessive noise emissions.
   4. Incorporate stringent drift elimination specifications for evaporative cooling towers.
   5. Prevention of accidential spills.
   6. Safe disposal of solid wastes.

D. Resource Management and Monitoring Plans
   1. Active ecosystem resource management programs can help to compensate for unavoidable losses
      a. Prescribed burning or crushing brush in chaparral habitats can reduce fire hazard and enhance wildlife carrying capacity.

b. Reforestation of potential timber lands can provide needed future resources and improve watershed and wildlife habitat.

c. Water sources can be supplied for wildlife and livestock with spring development and artificial impoundments.

d. Wetlands may be created with geothermal waste water if the quality is appropriate for surface disposal.

e. Nesting structures and reproductive habitat can be provided for a variety of wildlife species.

f. Cover and forage can be created for wildlife through revegetation.

2. Maximum public benefit from these improvements should be ensured by arranging access consistent with safe geothermal operations.

3. Monitoring programs are often required by regulatory or permitting agencies

   a. The effects of cooling tower drift on nearby vegetation can be evaluated by a variety of approaches.

   b. Documenting water quality conditions and the effects of accidential spills on aquatic ecosystems is a common requirement.

   c. It may be necessary to document the effectiveness of wildlife habitat enhancement programs or the status of certain important wildlife or plant populations.

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ELIOT ALLEN & ASSOCIATES INC.

URBAN & REGIONAL PLANNING / GEOTHERMAL ENERGY DEVELOPMENT / PUBLIC ADMINISTRATION & FINANCE

URBAN PLANNING FOR GEOTHERMAL DISTRICT HEATING

Eliot M. Allen, AICP
September, 1980

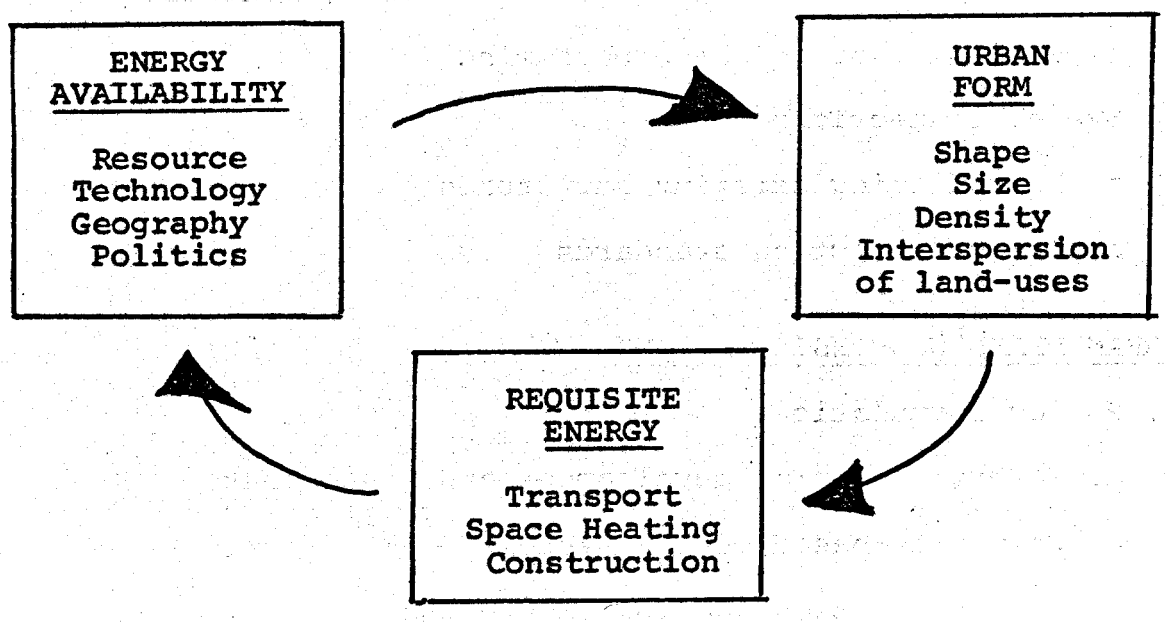
A. INTRODUCTION

1. Geothermal district heating relationships with urban planning.

   a. Historically community planning and development dictated amount of energy required for community operations (heating, transportation)

   b. Opportunity exists to plan and develop communities with energy efficiency as prime determinant

   c. District heating feasibilities and operational efficiencies directly dependent upon supportive urban planning system



(After Owens, 1979)

B. DISTRICT HEATING CONSIDERATIONS

1. Reservoir monitoring and long-term heat extraction design

2. Production and injection site identification

   a. Long-range land-use designation/acquisition/capital improvement programming

3. Heating Service Area Determinations

   a. Community heating atlas/load estimates (type, historical consumption, losses, industries)

   b. Land-use patterns and densities

   c. Growth projections

   d. Natural and man-made physical features

   e. Political boundaries

   f. Development sequence or phasing

4. Heating System Design Options

   a. Distribution piping systems

   b. Pumps, heat exchangers, storage tanks, controls

   c. Capital improvement programming

5. System Connections

   a. Retrofitting existing structures

   b. New construction standards

C. URBAN PLANNING CONSIDERATIONS

1. Policy formulation

   a. Natural resource development and management

   b. Community-based energy system

2. Policy integration and implementation

   a. Comprehensive plan

b. Zoning and subdivision ordinances

c. Urban area management agreements

d. Capital improvement program

3. Land-use patterns and densities (see Figures 1,2,3)

a. Location of land-use designations vis-a-vis reservoir characteristics and cascading potentials

b. Level of density controls vis-a-vis cost-effectiveness of heating service , as per sample table below:

Heat density MW/km^2 MBtu/h acre	Area	Category
over 70 0,97	Down-town - high risers	Very favorable
70 0,97 - 50 0,70	Down-town - multi-storied buildings	Favorable
80 0,70 - 20 0,28	City core - commerical bldg and multi-family apartment bldg	Possible
20 0,28 - 12 0,17	Residential areas - four two-family houses	Questionable
less 12 0,17	One-family houses	Not possible

c. Spatial arrangement of land-uses for optimum peaking effeciency

4. Zoning & Subdividing Factors

a. Density requirements

b. Lot sizes, setbacks, structure placement

c. Mixed-use zoning for cascaded applications

d. Public facility standards (streets, sidewalks, utility easements) re: distribution network consistency

5. Code Enforcement

a. Retrofitting existing structures

b. New construction standards

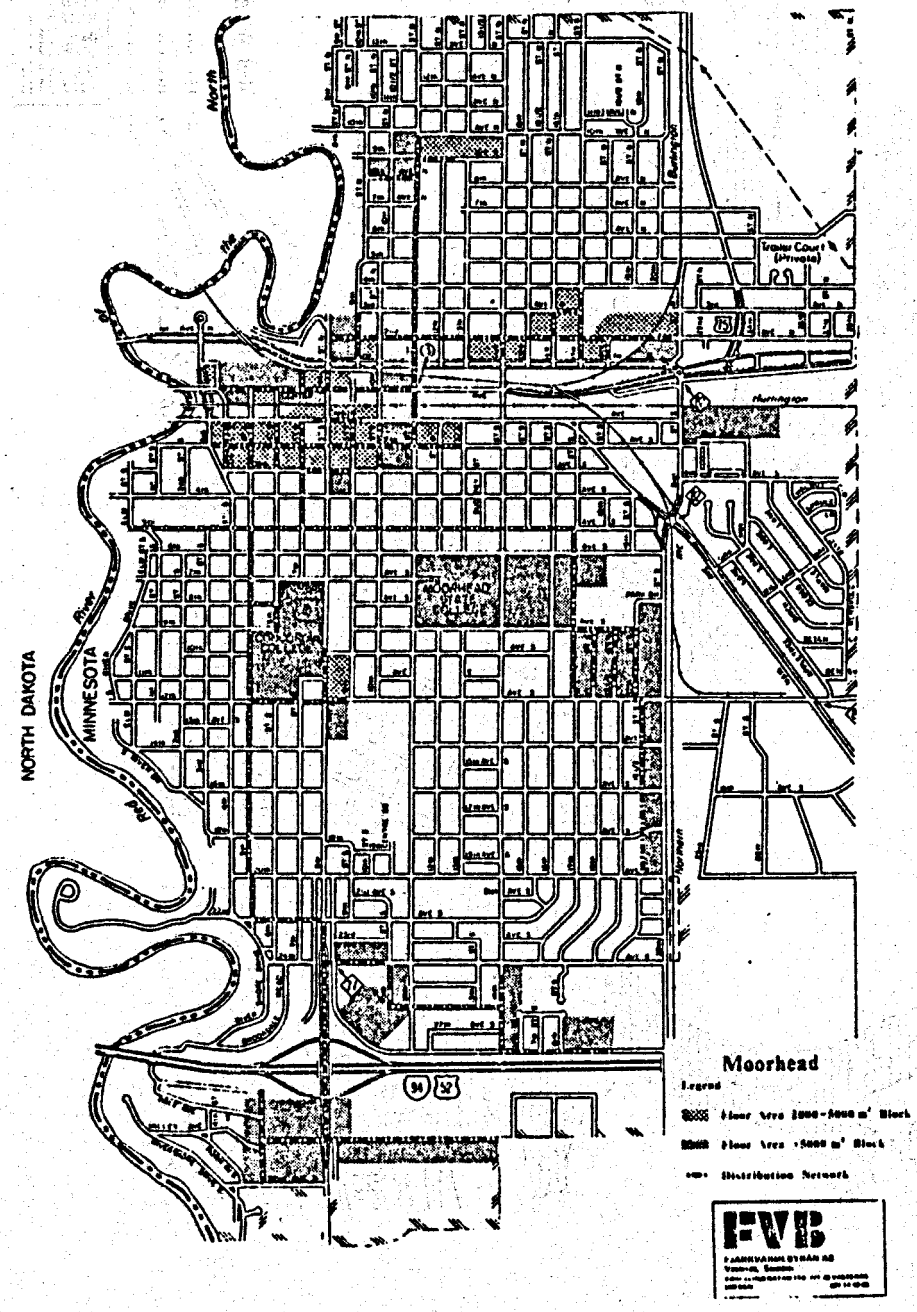


Fig. 1--Moorhead preliminary distribution system.

Three communities which have examined district heating possibilities.

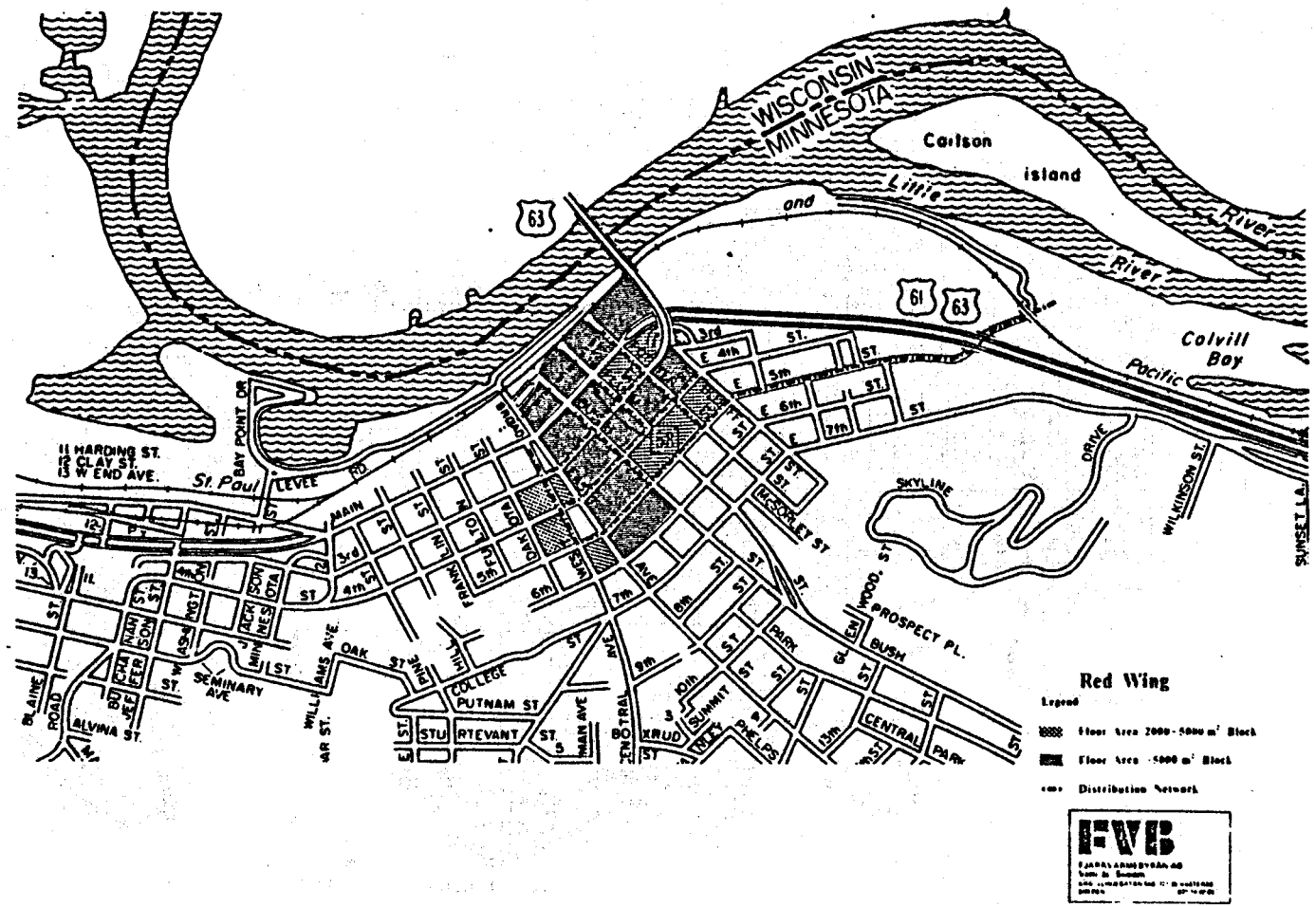


Fig. 2--Red Wing preliminary distribution system.

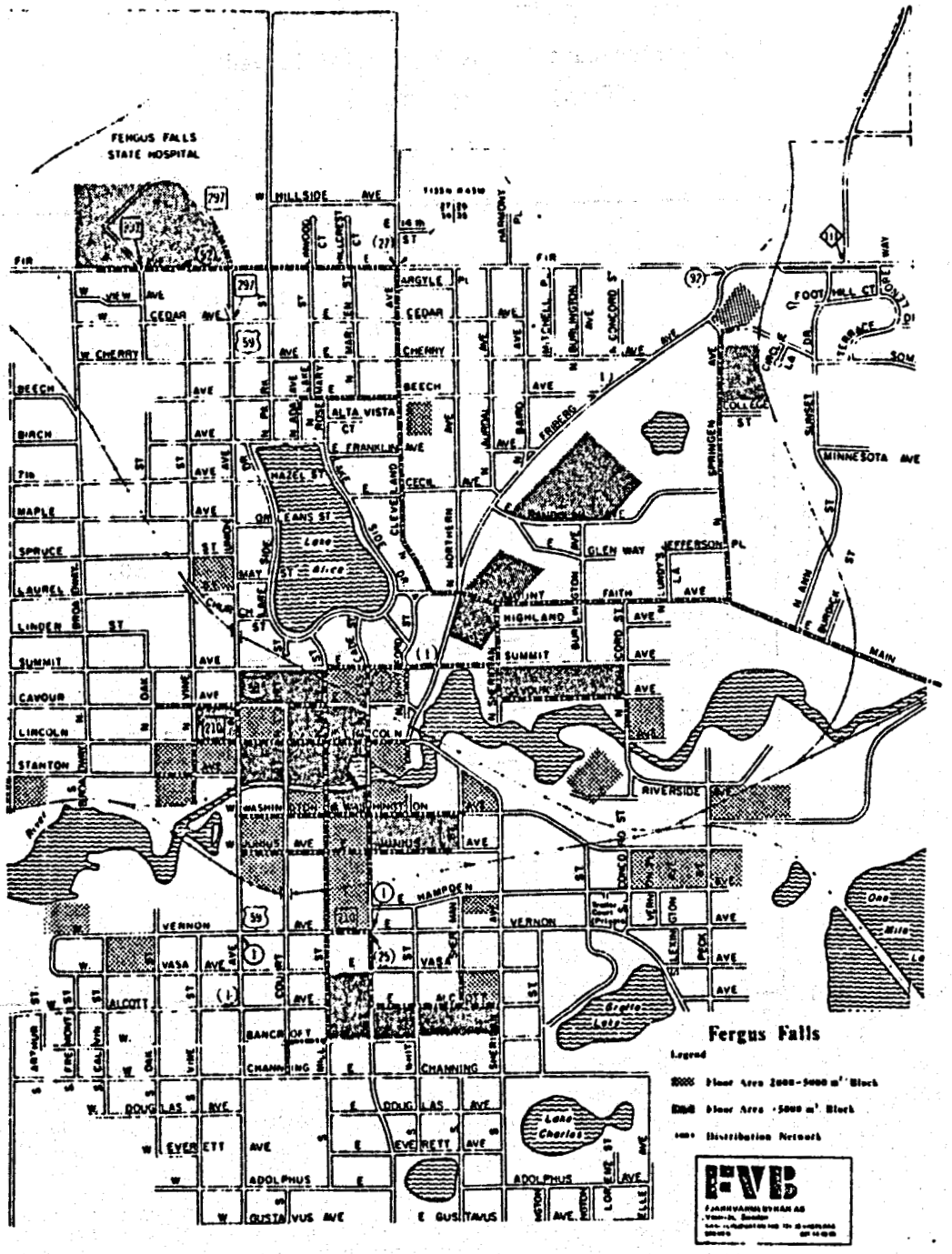


Fig. 3--Fergus Falls preliminary distribution system.

Figure 4.

Transmission Cost Versus Population Served
("Cross-country" costs)

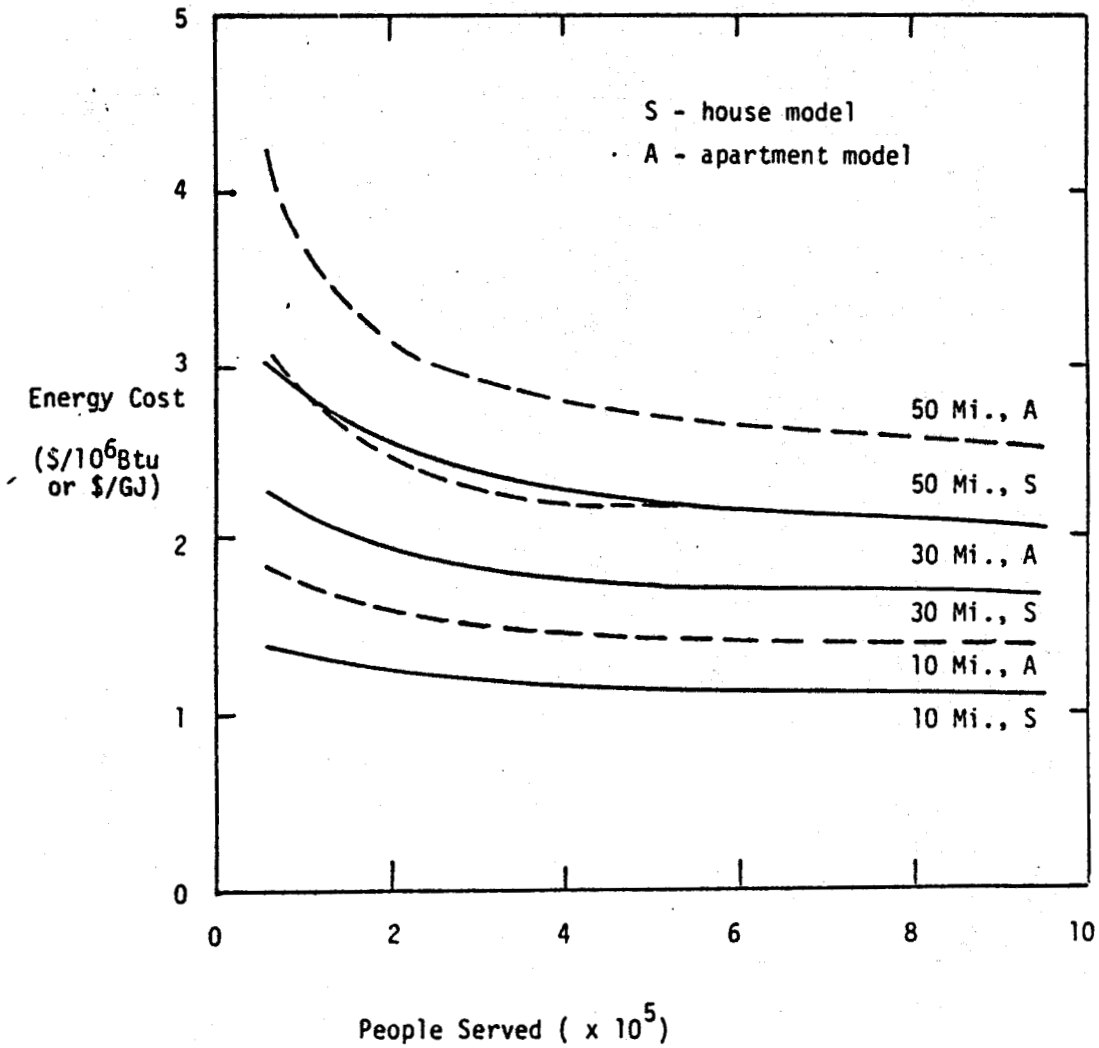
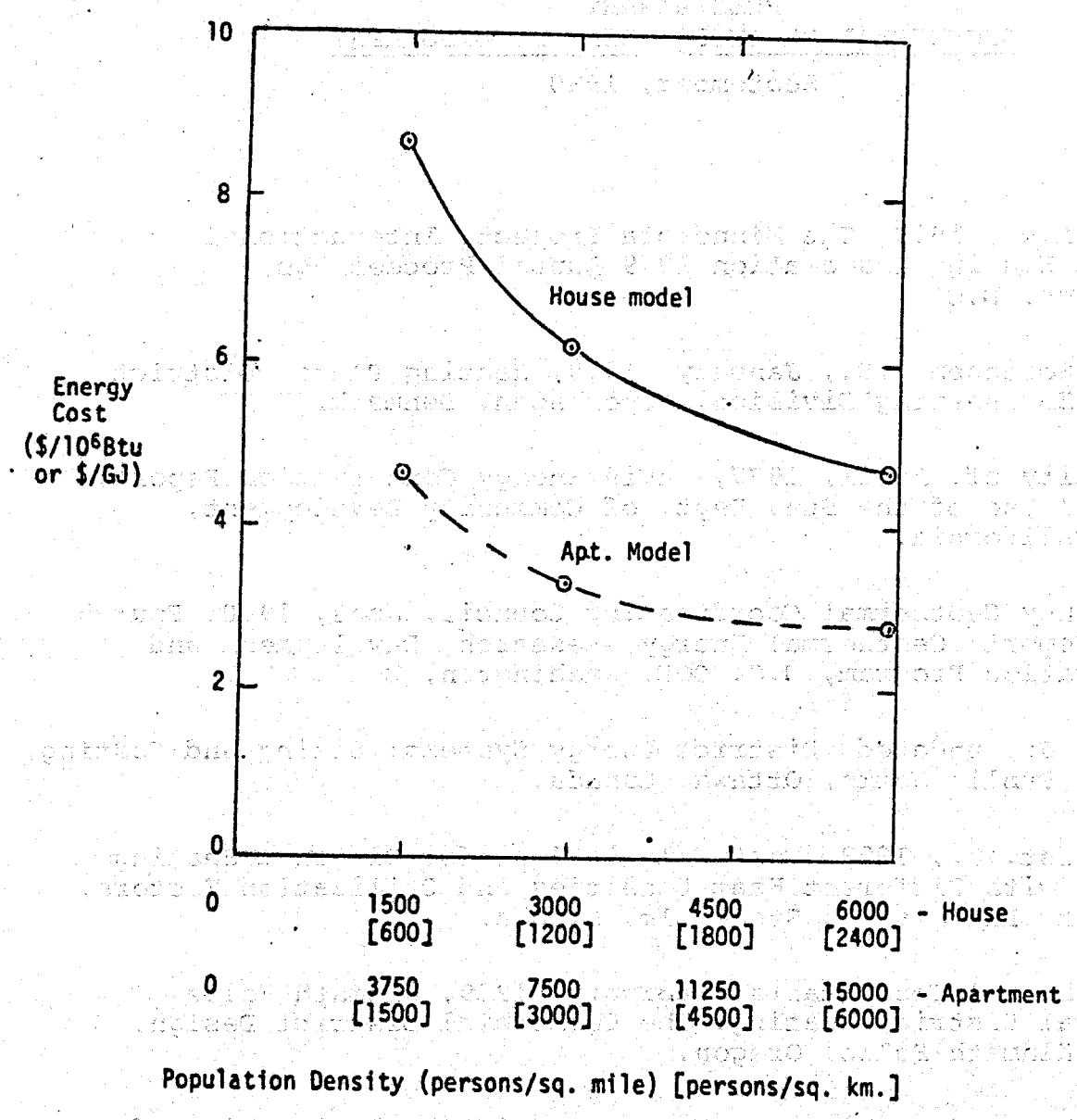


FIGURE 5.

Effect of Population Density on Energy Cost



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PRELIMINARY
GEOTHERMAL URBAN PLANNING BIBLIOGRAPHY

September, 1980

Barnes, M.H., 1979, The Minnesota Project, International District Heating Association 1979 Annual Proceedings, Washington, D.C.

Bruun & Sorensen A.S., January, 1979, Heating Plans, District Heating Engineering Division, Copenhagen, Denmark.

Davis, City of, April, 1977, Davis Energy Conservation Report: Practical Use of the Sun, Dept. of Community Development, Davis, California.

Interagency Geothermal Coordinating Council, June, 1980, Fourth Annual Report: Geothermal Energy, Research, Development and Demonstration Program, U.S. DOE, Washington, D.C.

Klassen, J., undated, District Energy Systems: Sizing and Costing, Canadian Public Works, Ottawa, Canada.

Lilljeqvist, J., 1978, Cost Calculations for District Heating Networks with Different Heat Densities and Utilization Factors, Stockholms Energiverk, Stockholm, Sweden.

LLC Geothermal Consultants, February, 1979, Klamath Falls Geothermal District Heating: The Commercial District Design, City of Klamath Falls, Oregon.

Mackie, B., and Mackie, M., November, 1977, Relationships of Energy to Land Use, Yamhill County Planning Department, McMinnville, Oregon.

Margen, P., June, 1976, New Types of Hot Water Distribution Systems for Low Density Heat Areas, Atomenergi A.B., Nykoping, Sweden.

McGregor, G.S., January, 1979, A New Energy Source: Natural Design for Energy Conservation, Community Development Department, Davis, California.

McGregor, G.S., May, 1979, Energy Conservation, Solar Access and the Law: Problems & Opportunities, Dept. of Community Development, Davis, California.

McGregor, G.S., 1979, Energy Conservation in Urban & Regional Planning: The Davis Experience, Community Development Department, Davis, California.

Ministry of Commerce, October, 1977, First Report from the Heat Plan Committee, Copenhagen, Denmark.

Ministry of Commerce, April, 1978, Second Report from the Heat Plan Committee, Copenhagen, Denmark.

Ministry of Commerce, March, 1979, Energy Report from the Ministry of Commerce, Copenhagen, Denmark.

Ministry of Commerce, June, 1979, Act on Heat Supply, Copenhagen, Denmark.

Morofsky, E.L., October, 1976, An Ecological Framework for Evaluating the Urban Impact of District Energy Systems, Technological Research & Development Branch, Dept. of Public Works, Ottawa, Canada.

Morofsky, D.L., October, 1977, District Energy Options and Urban Impacts, Dept. of Public Works, Ottawa, Canada.

Mounts, V., June, 1979, Study of Implementation of Mixed Use Zoning in Davis, California, 1977-1979, Dept. of Community Development, Davis, California.

National Energy Authority, May, 1975, The Energy Act, National Energy Authority, Reykjavike, Iceland.

Owens, S.E., 1980, Energy & Settlement Patterns, Built Environment, Volume 5, Number 4, pp. 282-286, London, Great Britain.

Pasqualetti, M.J., May, 1979, Geothermal Energy and the Environment: The Global Experience, Energy, Volume 5, pp. 111-165, London, Great Britain.

Pine, G.D., 1978, Economic Sensitivity Analyses of and the Effects of Urban Growth on District Heating System Implementation, International District Heating Association 1978 Annual Proceedings, pp. 289-314, Washington, D.C.

Sundberg, R.E. et al., June, 1979, Twin Cities Institutional Issues Study: Cogenerated Hot Water District Heating, International District Heating Association 1979 Annual Proceedings, Washington, D.C.

Wahlman, E., undated, Energy Conservation Through District Heating: A Step by Step Approach, Theorell & Martin Energikonsulter A.B., Sweden.

Jackson, P.L., and Maddocks, N., September, 1980, Applications of Location - Allocation Analysis for Energy Efficient Land-use Planning, O.S.U. Department of Geography, Corvallis, OR.

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URBAN & REGIONAL PLANNING / GEOTHERMAL ENERGY DEVELOPMENT / PUBLIC ADMINISTRATION & FINANCE

LAND-USE PLANNING & ZONING OF RURAL GEOTHERMAL RESOURCES IN OREGON

Steve Pfeiffer

Eliot Allen & Associates Inc.

September, 1980

ABSTRACT

In addition to the well-known geothermal development barriers of high risk and capital intensiveness, the resource is also subject to potential impediments in local land-use plans and zoning ordinances. One key to local geothermal development will lie in the successful utilization of Oregon's comprehensive planning process to inventory and designate geothermal areas where development is both encouraged and facilitated. A potential problem lies in the siting of geothermal industries in rural areas outside Urban Growth Boundaries, and the ability of such geothermal industries to qualify as allowable uses in Exclusive Farm Use zones. Local plan policies should be adopted which recognize the nature and utility of geothermal resources as they relate to the local economy and their specific application to agriculture. Exculsive Farm Use zoning provisions should further define specific industrial uses to which geothermal energy might be applied. In this manner, compatibility with Statewide Planning Goal 3 (Agricultural Lands) can be assured, consistent with the on-site application of Oregon's geothermal resources to select industrial uses.

The use of Oregon's significant geothermal resources as an alternative source of economical and renewable energy is receiving increasing attention throughout the state. To those communities located upon or in close proximity to geothermal reserves of sufficient quantity and temperature range, the promise of a renewable, relatively non-polluting and readily available energy supply means employment, revenue and economic growth otherwise forestalled by the rising costs, shortages and environmental problems commonly associated with traditional energy sources. To the potential industrial uses whose production is presently tied to low-yield energy requirements, the comparative economic advantages attendant to locations within such a community are significant and often outweigh most other considerations in its site selection process. For both, the increasing viability of geothermal energy offers tremendous potential for positive economic growth free of ever-present environmental, regulatory and availability costs which commonly plague energy supply considerations.

Yet the mere existence of geothermal reserves is not alone sufficient to render a community attractive to a potential industrial investor. In the site selection process, the advantages of geothermal energy lie not in its mere potential, but in its actual availability as a reliable source of energy for production purposes. Potential problems arise when direct utilization is thwarted by a lack of suitable sites which carry a comprehensive plan or zoning designation consistent with the type of development desired. In

short, the promise of geothermal energy may be of little consolation to an investor who is otherwise frustrated by the looming financial costs, delays and uncertainty typically associated with the need for zone or plan changes prior to any proposed development.

The key to geothermal development thus often lies in a community's successful utilization of Oregon's comprehensive planning process to identify and designate sites upon which geothermal exploitation is both encouraged and facilitated. A comprehensive plan designation and zone classification which supports the establishment and continued operation of a proposed geothermal-related use is of paramount importance to an individual or corporation willing to risk capital to develop a site. Conversely, the lack of such assurances may result in the decision to locate elsewhere.

Of primary concern to many Oregon communities is the potential for the location of geothermal-based industries upon a unique class of land; namely, agricultural land. Under Oregon law, such resource lands of a non-urban nature must be preserved through an Exclusive Farm Use Zone designation adopted pursuant to Oregon Revised Statutes, Chapter 215. In this manner, agricultural lands are to be protected from incompatible land use which threatens to diminish this valuable resource base.

Yet successful exploitation of Oregon's geothermal reserves is quite often dependent upon the location of potential industrial users on rural agricultural lands. Much like various mineral resources, geothermal fluids lie in aquifers of specific sites. Owing to the serious economic and technical problems associated with the

transportation of geothermal energy in its various forms from a rural extraction site, direct on-site utilization becomes essential. The transportation dilemma is further compounded by statutory provisions which may require re-injection of geothermal fluids into the reservoir of origin, thus necessitating a return transmission to the rural extraction site. See ORS 522.019.

The availability of farm products is also a factor in the location and efficiency of geothermal development. Many of the most efficient and more feasible uses for Oregon's low-medium temperature geothermal heat involves vegetable dehydration, milk pasturization, and similar industrial processing of agricultural products. As such, the transportation and energy savings which result from a close proximity to raw material sources further underscores the need for rural on-site geothermal development.

A key issue with respect to geothermal development in rural areas thus centers upon the availability of land zoned EFU for the location of geothermal-based industrial processing or production activities. This paper will focus upon the problems and opportunities associated with establishing such uses within EFU zones consistent with ORS Chapter 215 and State-Wide Planning Goal 3. This discussion is designed to outline various approaches available to local communities in their efforts to achieve maximum geothermal development opportunities consistent with the intent and language of EFU statutory provisions.

GOAL 3: AGRICULTURAL LANDS

Oregon, with the enactment of S.B. 100 in 1973, has established an innovative state-wide approach for dealing with land use problems stemming from rapid growth, pollution and a diminishing land resource base. The program requires all local cities and counties to develop comprehensive plans and implementing ordinances in accordance with State-Wide Planning Goals. These 19 goals became mandatory state-wide land use planning regulations in 1975 and 1976.

A key goal in the implementation of this system relates to land use activities on agricultural lands. Goal 3 - Agricultural Lands - defines such lands by soil type and requires that all lands so identified through the planning process must be protected for farm use and certain other activities through EFU zoning. Policies established within the Goal, and thus applicable to all local jurisdictions, seek to assure the preservation of maximum amounts of commercial agricultural land while preventing impacts stemming from incompatible uses which would otherwise diminish the amount and productivity of such lands.

The only notable exceptions to Goal 3 relate to agricultural lands which are:

(1) Inside an Urban Growth Boundary acknowledged by the Land Conservation and Development Commission pursuant to ORS Chapter 197; or

(2) Demonstrably lost to farm use through physical development or an irrevocable commitment to or need for such non-farm use. In both instances, agricultural land need not be zoned for exclusive

farm use where conformance with criteria established in State-Wide Goals 2 and 14, respectively, can be shown. However, it is beyond the scope of this discussion to address goal requirements which may render Goal 3 inapplicable in the appropriate situation. Questions concerning specific provisions of Goals 2 and 14 relating to Goal 3 application should be directed to the Department of Land Conservation and Development staff.

All lands within the scope of Goal 3 must be designated as Agricultural in the local comprehensive plan and be protected by an exclusive farm use zone adopted pursuant to ORS Chapter 215. ORS 215.203 identifies farm uses which are to be allowed in EFU zones adopted by the local jurisdiction. Similarly, ORS 215.213 establishes certain non-farm activities which may be permitted in EFU zones, as well as those which may be allowed as conditional uses subject to local governing body approval. As to these potential non-farm uses, local comprehensive plan policies and zoning ordinances should identify those specific uses to be allowed and any conditions to be applied. Local policies or ordinance provisions may not, however, impose unreasonable restrictions or regulations on accepted farming practices or structures in an EFU zone.

Finally, the treatment of existing non-farm uses within an EFU zone is also subject to the discretion of the local legislative body under ORS 215.215. Such uses may be treated as non-conforming uses and be re-established to their previous nature and extent upon destruction by fire or similar casualty. In addition, physically developed non-farm uses within such zones may be designated consistent with their character to the existing intensity of the use.

GEOTHERMAL DEVELOPMENT UNDER CHAPTER 215

The potential for the development and industrial utilization of geothermal fluids within EFU zones lies within the local jurisdiction's application of the permitted use language established by ORS Chapter 215. For example, the definition of "farm use" found at ORS 215.203(2)(a) suggests a full range of possible geothermal-related industrial activities which, if so interpreted at the local level, must be allowed in such zones. Other uses permitted under the statute directly incorporate various stages of the geothermal exploration and generation process. Similarly, the discretion afforded local treatment of existing non-farm uses presents significant opportunities for the conversion of existing facilities to industrial processes conducive to geothermal application. These various alternatives, as discussed in detail below, may be addressed through the community's planning process in a manner which suggests the appropriate development of local rural geothermal reserves.

EXPLORATION AND PRODUCTION

ORS 215.213(1)(f) expressly establishes geothermal exploration activities as a permitted non-farm use in any area zoned for exclusive farm use. Such activities are defined as all:

> Operations for the exploration of geothermal resources as defined by ORS 522.005.

ORS 522.005(7) broadly defines "geothermal resources" to include:

> The natural heat of the earth. The energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from, the natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases, and steam, in whatever form, found below the surface of the earth, exclusive of helium or of oil, hydrocarbon gas or other

hydrocarbon substances, but including specifically:

(a) All products of geothermal processes, embracing indigenous steam, hot water and hot brines;

(b) Steam and other gases, hot water and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations;

(c) Heat or other associated energy found in geothermal formations; and

(d) Any byproduct derived from them.

It seems clear that any exploratory operation designed to locate the resource may be permitted outright in EFU zones. Local jurisdictions should nevertheless clearly address this use and any applicable conditions through policy statements within the comprehensive plan and attendant implementing ordinance provisions.

Once a geothermal reservoir has been located, however, subsequent production or mining operations and facilities are to be permitted within local EFU zones only as a conditional use.

ORS 215.213 provides that:

> "(2) The following non-farm uses may be established subject to the approval of the governing body or its designate, in any area zoned for exclusive farm use:
>
> > "(a) Operations conducted for the mining and processing of geothermal resources as defined by ORS 522.005."

The local zoning ordinance must identify such uses as permissible within EFU zones subject to conditional use approval. Production activities would presumably be distinguished administratively by the actual delivery of the resource, in whatever form, to the surface, in a quantity sufficient for utilization as an energy source.

This distinction is not without its impact upon the local regulation of uses within an EFU zone and the possible resulting impacts

upon geothermal utilization. The additional burdens imposed upon the legislative body by the conditional use process are significant. While constructive, the requisite hearings, provision of notice and staff analyses consume the time, energy and moneys of all involved. Moreover, the proponents of geothermal production will lament the uncertainty, cost and delays inherent within the procedure.

Yet, the distinction is also understandable in light of the express legislative intent behind EFU zoning. By its very nature, the conditional use process affords an opportunity to impose mitigating conditions upon certain non-farm activities which may otherwise prove incompatible with commercial agricultural enterprise within the area. To this end, the local plan should include policies designed to assure Goal 3 conformance through the application of such specific conditions to rural geothermal extraction and generation operations as are appropriate. In short, such uses are clearly permissible in EFU zones. However, Goal conformance may require the imposition of conditions which effectively preclude any adverse impacts upon adjacent agricultural activities.

GEOTHERMAL INDUSTRY AS A "FARM USE"

Geothermal energy is directly applicable to a number of industrial processes involving agricultural products. Milk and cheese processing, vegetable dehydration, grain ethanol production, and greenhouses are merely a few examples of various processing operations ideally suited to the low-yield energy derived from Oregon's geothermal fluids. The direct application of geothermal resources in these processes also eliminates the costly conversion to thermal

energy which is often required with traditional fuel sources. Indeed, agricultural processing industries of this type represent the largest and most efficient category of potential geothermal consumers.

Industries utilizing geothermal heat in the processing of agricultural products are potentially permitted outright in EFU zones as "farm uses." Under ORS 215.203(2)(a), "farm use" is defined as:

> "The current employment of land including that portion of such lands under buildings supporting accepted farming practices for the purpose of obtaining a profit in money by raising, harvesting and selling crops or by the feeding, breeding, management and sale of, or the produce of, livestock, poultry, fur-bearing animals or honeybees or for dairying and the sale of dairy products or any other agricultural or horticultural use or animal husbandry or any combination thereof."

More importantly, the definition continues:

> "The preparation and storage of the products raised on such land for man's use or animal use and the disposal by marketing or otherwise." (Emphasis added.)

Any uses within the scope of this definition must be identified as permissible uses within an EFU zone adopted by any local jurisdiction.

The phrase "preparation and storage of products raised on such lands" clearly seems to include the processing of agricultural products through the application of geothermal heat. For example, the dehydration of onions and similar vegetables is a common means of minimizing spoilage while reducing bulk and weight for shipping and food preparation purposes. The process, which involves the direct application of heat as a drying agent, equates to the "preparation" of agricultural products "for man's use* * *and the disposal by marketing." As such, the establishment of industrial facilities

utilizing geothermal heat in this and similar procedures is a "farm use" under the statute and thus is permissible in local EFU zones.

This analysis could be applied to any industrial process, ranging from ethanol production to greenhouse horticultural operations, which use agricultural products as a raw material source. Again, the local comprehensive plan should include policies establishing such activities as appropriate farm uses in the rural geothermal areas zoned EFU. Similarly, zoning ordinance provisions should identify specific geothermal-based activities which are consistent with the farm-use definition set forth in the statute. ORS 215.203 does not attempt to list every specific permissible use. Rather, it permits each local community to assess its unique needs and resources and further refine the broad classifications of permissible uses to identify those particular uses appropriate for the local situation.

Numerous issues arise, however, with respect to such an application of ORS 215.203. For example, what is the appropriate scale or intensity of geothermal processing operations which are characterized as farm uses? This raises a question as to whether the language "products raised on such lands" refers merely to <u>any</u> lands "used exclusively for farm use" or requires a more limited raw material source to include only those products raised on lands held by the industrial processor or farmer involved. If the former interpretation prevails, a vegetable dehydrating facility located on land zoned EFU could receive products raised on adjacent lands, as well as those grown in its own fields.

Conversely, the more restrictive view would limit the processor's raw material source, thereby clearly impacting the extent, or even feasibility, of efficient exploitation of the geothermal reservoir involved. The more appropriate interpretation would permit geothermal processing of <u>any</u> agricultural product, regardless of source, on the premise that the benefits of an expanded market for local products and the enhanced efficiency of a centralized, high-volume processing facility would in fact encourage continued farm production.

The type and level of public facilities and services to be made available to the rural industrial site may also pose limitations on the scale of such activities. State-Wide Planning Goal 11 - Public Facilities and Services - provides that such facilities and services shall be limited to those "appropriate for, but limited to, the needs and requirements" of the rural use to be served. The goal further defines "rural facilities and services" as "the facilities and services which the governing body determines to be suitable and appropriate solely for the needs of rural use."

The local community may thus provide such services as deemed necessary to support appropriate rural uses as identified through the local planning process. If geothermal processing facilities are established as an appropriate farm use on lands zoned EFU, public facilities and services of the type and extent essential to conduct these uses, such as sewer and water service, fire protection and geothermal energy, may be permitted in conformance with Goal 11. Local plans should address this issue through appropriate plan

policies, capital improvement programs or commitments and implementation measures consistent with the community's ability to provide such services if necessary.

The type of industrial uses of geothermal energy which may be deemed as farm use is yet another potential issue. As noted earlier, it seems clear that such activities must involve the use of agricultural products as the integral raw material source. For example, the kiln drying of lumber is probably not equivalent to the uses set forth in the statute. However, the language "preparation and storage" of such products arguably includes a broad list of industrial activities conducive to geothermal application. For example, it seems likely that poultry dressing, fruit and vegetable canning, and, where necessary, the indefinite storage of numerous finished products, are but a few of these uses which could be considered allowable farm uses. Packaging, freezing or bottling activities for purposes of "disposal by marketing or otherwise" would also be appropriate ancillary uses. At each stage of such operations, geothermal resources may be provided as an alternative source of energy, subject only to the potential limitations on generation facilities within EFU zones, found at ORS 215.213(2)(b).

In short, the broad definition of farm use outlined in Chapter 215 provides local jurisdictions with substantial discretion in determining which, if any, geothermal-related industries are to be permitted in areas zoned for exclusive farm use. In determining whether such uses are appropriate, given the community's specific

agricultural needs and resources, the planning process must take into account the scale and intensity of use, as well as the type of activity involved.

Upon concluding that a potential rural industry is in fact a "farm use," the comprehensive plan and implementing ordinance should specifically establish each such use as permissible and consistent with the EFU zone's primary purpose of protecting agricultural lands.

EXISTING INDUSTRIES IN EFU ZONES

The presence of existing industrial facilities in areas subsequently zoned for exclusive farm use offers additional opportunities for the industrial utilization of rural geothermal resources. ORS 215.215(1) provides that:

> "If a nonfarm use exists in an exclusive farm use zone and is unintentionally destroyed by fire, other casualty or natural disaster, the county may allow by its zoning regulations such use to be re-established to its previous nature and extent, but the re-establishment shall meet all other building, plumbing, sanitation and other codes, ordinances and permit requirements."

The continuance of non-conforming industrial uses in newly adopted EFU zones is further supported in ORS 215.130(5), which provides:

> "The lawful use of any building, structure or land at the time of the enactment or amendment of any zoning ordinance or regulation may be continued. Alteration of any such use may be permitted or continued to reasonably continue the use.* * *"

The governing body may thus permit the continued operation of industrial uses existing within EFU zones prior to the adoption of such zones. Moreover, such uses may be altered provided such alterations do not substantially change the intensity or character of the original use.

The value of this local discretion for purposes of geothermal development lies in the ability to convert existing industrial operations to consumers of geothermal energy. Where a non-conforming industrial facility is located upon or in close proximity to a geothermal reservoir of sufficient temperature and quantity, the potential for such conversion may be significant, depending upon the type of activity involved and the nature of its energy requirements.

Under Chapter 215, such a conversion appears permissible:

(1) Where an existing energy supply source could be replaced with a form of geothermal energy; or

(2) Where a non-farm industrial use could be replaced with an agricultural processing use of the type held to be "farm use;" or

(3) Where the proposed agricultural-related use is reasonably similar to the original industrial use.

It appears unlikely, however, that an existing structure housing a non-farm use could be later occupied by a non-farm use of a wholly different nature. Moreover, it is clear that the scale of a new use cannot be intensified, whether upon conversion or re-establishment subsequent to destruction. Nonetheless, local communities should consider possible plan and ordinance language which permits the re-establishment of non-conforming industrial uses as a means of facilitating potential development of the area's rural geothermal reserves, where possible.

The zoning of existing rural industries within an EFU zone for industrial use offers an alternative approach to the establishment of such industries as potential geothermal customers. Under ORS 215.215 (2), the governing body may, consistent with ORS 215.243:

> "Zone for the appropriate non-farm use one or more lots or parcels in the interior of an exclusive farm use zone if the lots or parcels were physically developed for non-farm use prior to the establishment of the exclusive farm use zone."

In other words, an area which is clearly physically developed in an industrial manner may be deemed lost to farm use and thus may be zoned consistent with existing development. Under this approach, such non-farm zoning may permit the continuance of existing non-farm industrial uses free of the limitations imposed upon non-conforming uses under ORS 215.215(1).

Notwithstanding the alternate zoning, non-farm uses permitted pursuant to this provision must also conform to the legislative policy on agricultural lands established in ORS 215.243. In essence, this provision expresses a legislative judgment that agricultural land should be preserved in large blocks and protected from conflicts between farm and urban activities through the adoption of EFU zoning. As a result, any non-farm zone adopted under ORS 215.215(2) should contain mitigating provisions designed to assure that uses permitted therein will not create impacts incompatible with surrounding agricultural activities. Plan policies and ordinances criteria again provide the opportunity to assure such non-farm uses are permitted only upon a demonstration of conformity with established legislative intent.

On the other hand, the establishment of agricultural processing industries provides additional markets for local products and thus stimulate agricultural production within the area. As such, the local plan could also provide policies which encourage or require that any alteration of uses within such non-farm zones

presents new market opportunities for locally grown products.

Alternative policies requiring buffering, area coverage limitations, or similar mitigating criteria, could also serve to assure conformity with the purpose of EFU zoning.

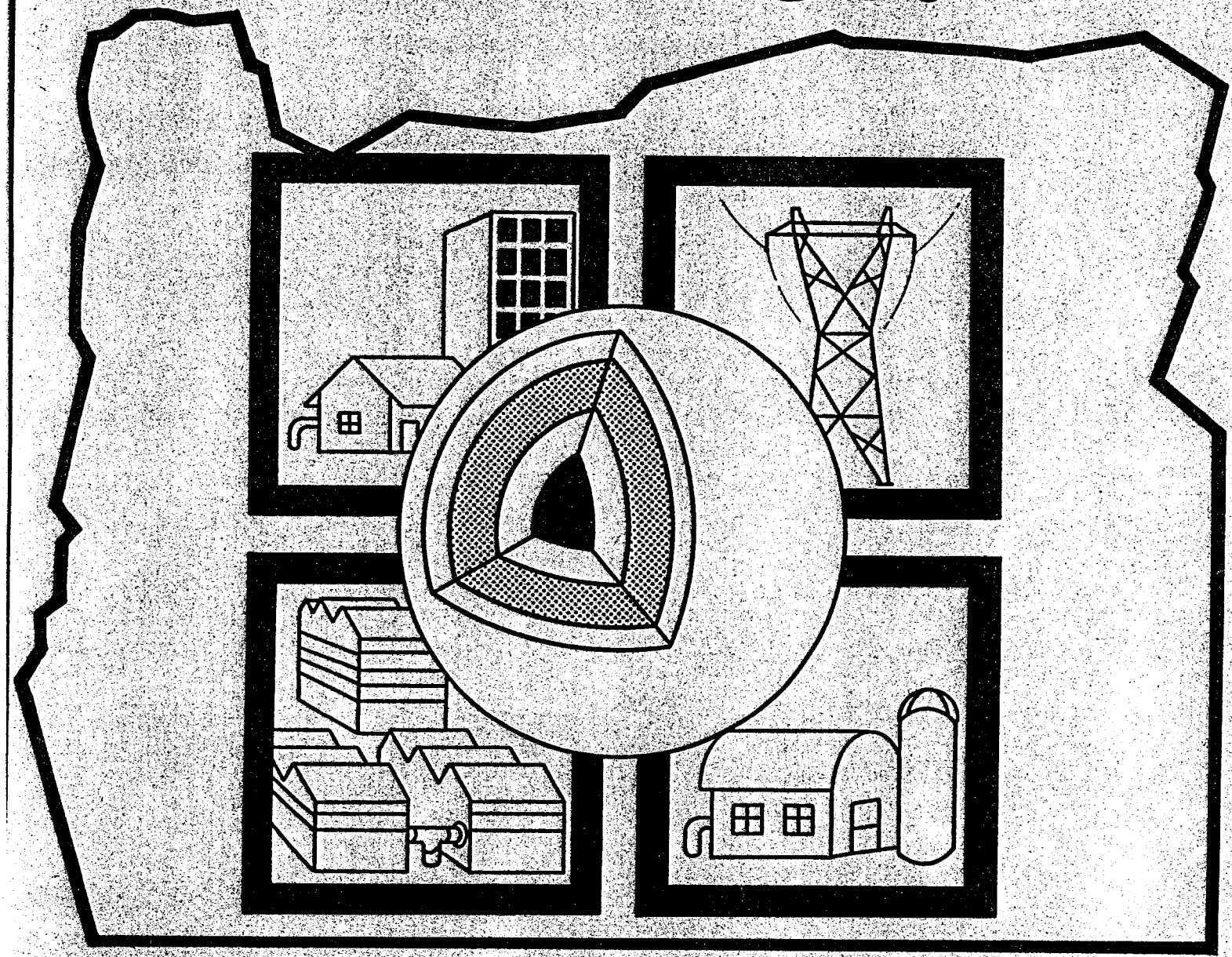
CONCLUSION

The zoning of Oregon's agricultural lands for exclusive farm use does not preclude the potential use of those lands for rural agricultural development and utilization. The Oregon Legislature, in ORS Chapter 215 and Goal 3, established a framework of potential farm and non-farm uses deemed consistent with the protection and continued productivity of the state's agricultural resource base. Within this full range of permissible uses, numerous opportunities exist for the location of industrial operations which are ideally suited to geothermal application. To a large extent, the discretion to permit such development lies with the applicable local governing body, subject only to the broad use categorizations and legislative policy established by statute and the State-Wide Goals.

The local planning process provides the appropriate mechanism for the exercise of this discretion. Plan policies should be adopted which recognize the nature and utility of the unique geothermal resource as it relates to both the local economy and its specific application to agricultural-related activities. EFU zoning provisions should further define specific industrial uses to which geothermal energy might be applied, given local agricultural potential and the character of the resource.

In this manner, compatibility with Goal 3 can be assured, consistent with the on-site application of Oregon's geothermal resources to select industrial uses.

OREGON



GEOTHERMAL

INSTITUTIONAL PROGRAMS

INFORMATION AND ASSISTANCE

FOR GEOTHERMAL DEVELOPMENT

IN OREGON

INFORMATION SOURCES

Information regarding geothermal development and use is available from a variety of public and private sources. Federal and state agencies responsible for alternate energy planning, development, and regulation can provide information concerning technical, economic, institutional aspects, and financial support for geothermal development and use. Local sources of information include universities, planning departments, area economic development groups, the Energy Extension Service, and local energy centers. Private consultants can also provide valuable assistance ranging from resource identification to project and institutional management. It is suggested that initial contact be made with the Oregon Department of Energy and U.S. Department of Energy to determine the most appropriate sources of information. Several of the key contacts are listed below:

U.S. Department of Energy (U.S. DOE)

U.S. DOE administers programs which deal with all aspects of geothermal energy from research and development to construction of demonstration projects. National programs are managed from U.S. DOE headquarters in Washington, D.C. The DOE regional representative's office in Seattle administers many of these programs in the Pacific Northwest.

U.S. Department of Energy
Division of Geothermal Energy
12th and Pennsylvania NW
Federal Building
Washington, D.C. 20461
(202) 633-8106

U.S. Department of Energy
Geothermal Program
Federal Building 1910
916 2nd Avenue
Seattle, Wash. 98174
(206) 442-2820

Oregon Department of Energy (ODOE)

ODOE administers a state program to promote commercialization of geothermal resources. ODOE can provide information and assistance concerning resource areas, development status, incentives and funding sources, technical data on resource applications, and the legal and institutional framework which guides development.

Oregon has adopted model legislation enabling communities to form publicly-owned geothermal heating districts to develop and beneficially manage local geothermal resources. ODOE can provide information about the formation of geothermal heating districts.

Oregon Department of Energy
Geothermal Program
102 Labor and Industries Building
Salem, Oregon 97310
(503) 378-4040 or Toll Free 1-800-452-7813

Oregon Institute of Technology - Geo-Heat Utilization Center

The Geo-Heat Utilization Center manages a variety of geothermal programs which emphasize direct heat applications. These efforts include regional planning, technical assistance, market studies, and outreach activities. The Center publishes a quarterly bulletin which highlights current activities and technologies in the geothermal direct use field. Information is available concerning planning, permitting, construction, economics and resource evaluation, and current development status for direct use applications at the state, national, and international level.

Geo-Heat Utilization Center
Oregon Institute of Technology
Klamath Falls, Oregon 97601
(503) 882-6321, Ext. 267

Oregon Department of Geology and Mineral Industries (DOGAMI)

The Department participates in a geothermal program with the U.S. DOE and U.S. Geological Survey to assess geothermal resource areas in Oregon. DOGAMI can provide valuable information concerning resource characteristics and drilling permit procedures. DOGAMI publishes an annual review of exploration activities, generally in a spring edition of Oregon Geology Magazine.

Oregon Department of Geology & Mineral Industries
1069 State Office Building
Portland, Oregon 97201
(503) 229-5580

Geothermal Resources Council (GRC)

The GRC is a non-profit professional organization dedicated to information dissemination and support of geothermal education programs. GRC offers seminars and technical training sessions and publishes special reports, a monthly bulletin, and a directory. GRC can provide references and contacts for all aspects of geothermal development and use.

Geothermal Resources Council
P.O. Box 98
Davis, Calif. 95616
(916) 758-2360

TECHNICAL ASSISTANCE

As a part of the U.S. Department of Energy's geothermal program, technical asssitance is available, at no cost, to private, public, or corporate entities interested in using geothermal resources. The program is intended to provide assistance to persons with little or no experience in the geothermal field in order to promote rapid development of geothermal energy. The amount of assistance is limited in recognition of the work of private organizations involved in this area. Assistance is provided, as requested, on a first come, first served basis.

The Geo-Heat Utilization Center can provide assistance in the form of limited resource evaluation, engineering and economic feasibility studies, materials selection, corrosion problems, conceptual design, institutional factors, and consultation with independent engineers, geologists, planners, managers and other geothermal consultants.

Geo-Heat Utilization Center
Technical Assistance Program
Oregon Institute of Technology
Klamath Falls, Oregon 97601
(503) 882-6321, Ext. 267

In a similar manner, the University of Utah Research Institute can provide service for geologic, geophysical and other resource evaluation assistance.

University of Utah Research Institute
Earth Science Laboratory
User-Assistance Program
Research Park
420 Chipeta Way, Suite 120
Salt Lake City, Utah 84108
(801) 581-5283