

**GEOHERMAL RESOURCES,
PRESENT AND FUTURE DEMAND FOR POWER
& LEGISLATION IN THE STATE OF WYOMING**

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THE GEOLOGICAL SURVEY OF WYOMING

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ABOUT THE COVER: The geyser pictured on the
cover occurs in Yellowstone National Park,
a known geothermal resource area in Wyoming.

INTRODUCTION

This report summarizes data on thermal springs and wells in Wyoming, exclusive of Yellowstone Park. The presentation includes a map showing general spring and well locations outside the Park and lands in Wyoming that have been classified as being prospectively of geothermal value. Locations and geothermal data on the springs and wells are tabulated and a short table of chemical analyses of spring waters is also presented.

Although thermal data constitute most of the material presented, this report also summarizes the present and future demands for electrical energy in Wyoming, and reviews state legislation pertaining to exploration near thermal springs. A list of state and federal agencies is included so that interested parties may obtain copies of pertinent legislation and information on the status of land.

KNOWN GEOTHERMAL RESOURCE AREA (KGRA)

Yellowstone Park is the only area in Wyoming that presently qualifies as a KGRA. It is

unlikely that this area will be released for the development of geothermal power.

OTHER THERMAL AREAS IN WYOMING

Generalized geology of Wyoming is shown in Figure 1 while Figure 2 shows the locations of thermal springs and wells outside Yellowstone Park and the lands in Wyoming that may be valuable prospectively for geothermal resources (after Godwin *et al.*, 1971; Laraway, 1971). The thermal data and more precise locations for each spring, spring area and well are listed in Table 1, together with comments, references and updated general geology.

Most of the data in Table 1 came from

Waring (1965). Other data came from D.L. Blackstone, Jr., of the University of Wyoming and J.D. Love, of the U.S. Geological Survey (USGS).

Table 2 lists all of the recent chemical analyses that I could find for the locations in Table 1. I would like to thank D.E. White of the USGS for copies of analyses of waters from the Auburn and Flagg Ranch hot springs.

REGIONAL GEOLOGY AND GENERAL COMMENTS ON SPRINGS

With the exception of the thrust belt, the geology of Wyoming is characterized by north-south to northwest trending, asymmetrical mountain uplifts in which the Precambrian basement is exposed. Prior to the Laramide deformation, the basement was overlain by Paleozoic and Mesozoic marine sediments ranging up to 4570 meters thick. Differential relief of the basement is as great as 10,690 m. and, in the intermountain basins, late Cretaceous and Cenozoic sediments have accumulated with thicknesses exceeding 4570 m. In the thrust belt, Cretaceous and older rocks were thrust from west to east, generally placing Cretaceous and older units over younger rocks.

The Yellowstone-Absaroka-Jackson area is the largest volcanic field in Wyoming. Volcanism in the Yellowstone-Absaroka region started in the Eocene (Love *et al.*, 1972). There is no record of Oligocene and Miocene

volcanism in the region, but there are some Pliocene volcanic units in the Yellowstone area (Love *et al.*, 1972).

The Yellowstone region was the site of extensive rhyolitic and basaltic volcanism in the Pleistocene (Christiansen and Blank, 1972). There was extensive Eocene volcanism in the area that is now known as Jackson Hole (Love *et al.*, 1972). From the Miocene to the Pleistocene, subsidence of Jackson Hole was coincident with extensive activity throughout the region (Love, 1956, 1968).

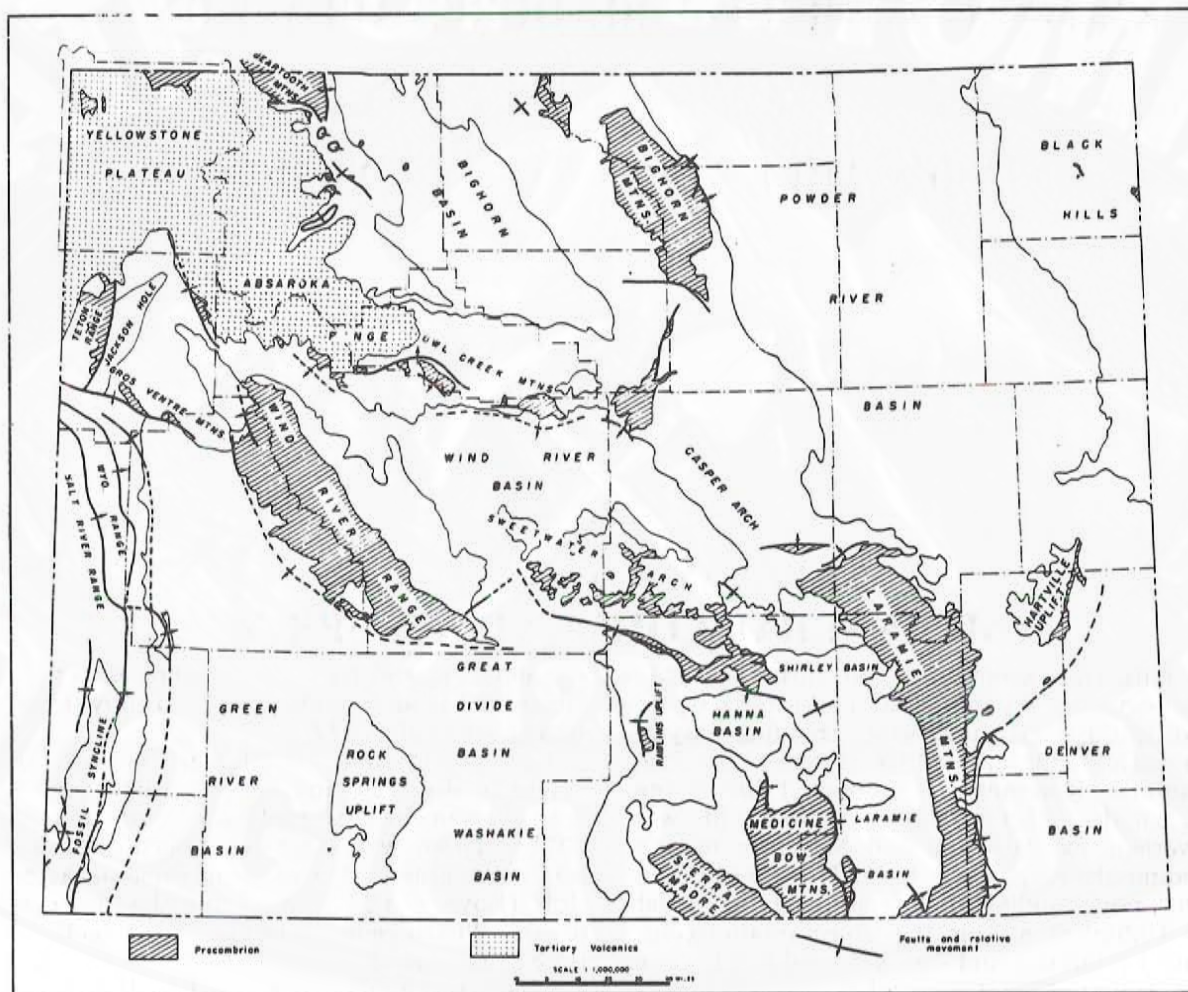
The Leucite, Rattlesnake and Black Hills are other volcanic fields in Wyoming (see Fig. 2). Volcanic rocks in the Leucite Hills have been dated at ≤ 1.25 million years (Bradley, 1961), or Pleistocene. In the Rattlesnake Hills, the volcanic rocks are middle to upper Eocene (Pekarek, 1974). Volcanic rocks in the Black Hills are considered to be Eocene and Oligocene (Houston, 1963, 1969).

Twenty-four of the springs or spring systems listed in Table 1 issue from folded or faulted Phanerozoic sediments. Of the remaining three, one issues from Precambrian granite. The other two issue from Pliocene and Pleistocene volcanic units, respectively. Five of the springs (Flagg Ranch, Jackson Lake, Kelly, Teton Valley, and the Rattlesnake Hills) are within eight kilometers of Late Tertiary eruptive centers; the others are

more than 16 km from Tertiary volcanic fields (Fig. 2).

The correlation between thermal spring activity and Tertiary volcanism outside the Yellowstone-Jackson-Absaroka area is obscure. For example, I could not find evidence for hot springs in the Leucite Hills, an area where lavas have been dated at 1.25 million years (Bradley, 1961).

FIGURE 1: INDEX MAP OF WYOMING SHOWING MAJOR STRUCTURAL FEATURES



USES OF GEOTHERMAL RESOURCES IN WYOMING

Geothermal resources in Wyoming have been used for hot waters at resorts and sanitariums and for irrigation (Table 1). The Wyoming Geological Survey and other

state agencies receive inquiries about the geothermal resources of Wyoming, but there is no evidence for active exploration.

FIGURE 2: THERMAL SPRINGS, WELLS AND OTHER GEOTHERMAL DATA IN WYOMING. Solid circles represent locations of thermal springs or wells. Open circles represent locations of published heat flows (Blackwell, 1969; Sass et al., 1971); solid squares represent locations of estimated heat flows (Blackwell, 1969). Solid triangles represent locations of gradients, in brackets, determined by Blackwell (1969). Heat flows in microcal/cm²sec, gradients in °C/km. Tertiary volcanic fields (after Houston, 1963): A=Yellowstone-Absaroka; B=Leucite Hills; C=Rattlesnake Hills; D=Black Hills; J=Jackson Source Area. See Table 1 for locations of springs and wells. Solid black lines outline lands valuable prospectively for geothermal resources.

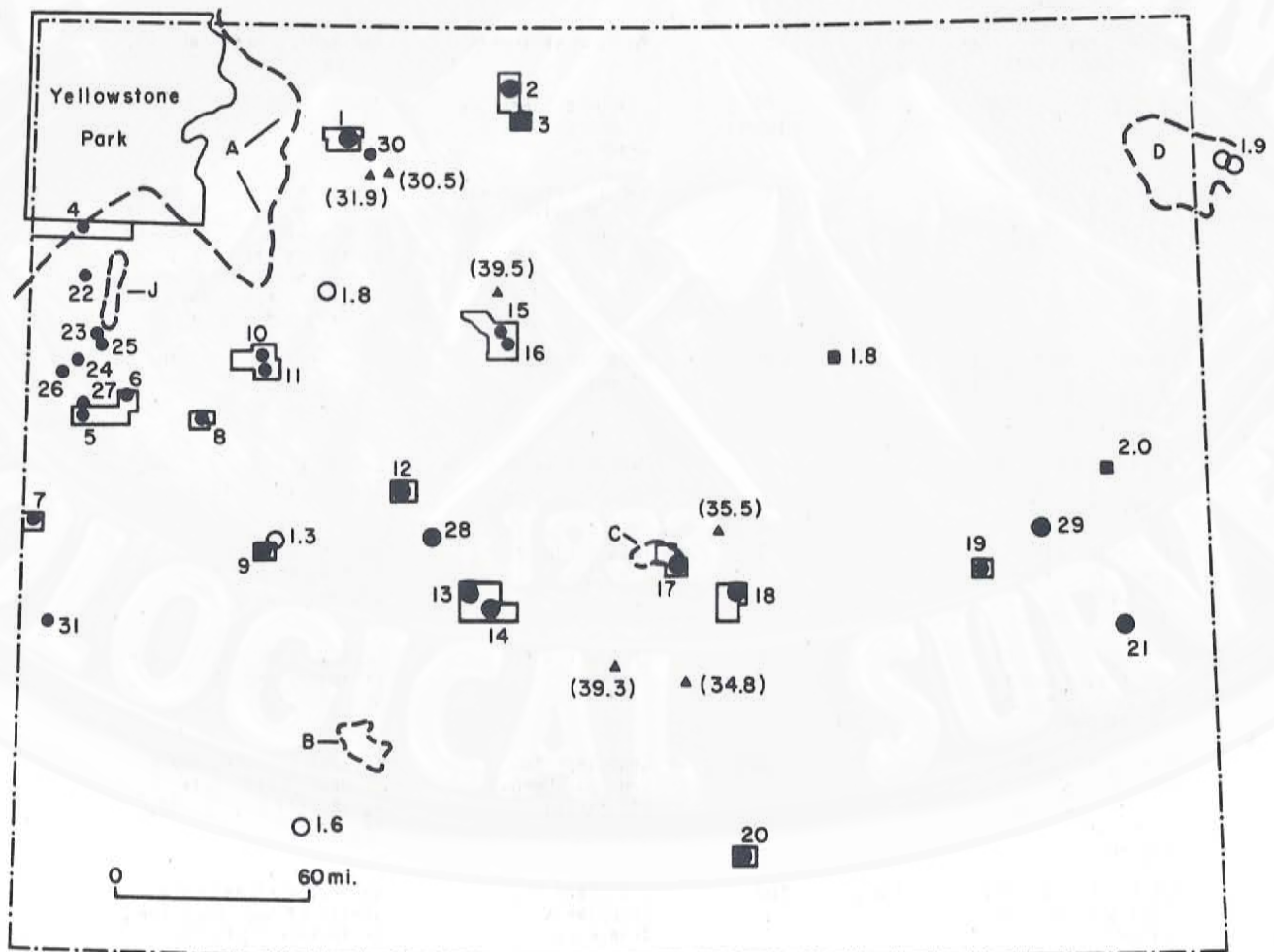


TABLE 1: GEOTHERMAL LOCATIONS IN WYOMING

No., Fig. 2	Name or Location	Temp. °C	Flow gal/min	Geology	Comments & References
1	DeMaris Hot Springs. Four miles south- west of Cody, Wyoming.	24-38	50-100	Dinwoody & Park City Fm. (Permian)	Several Springs. Resort and sanitarium. Deposits of sulfur and travertine. Refs. 1, 16, 17, 18, 19, 20, 39, 40, 46, 48, 59, 63.
2	T.55N., R.94W., in Sheep Canyon of the Big Horn River, near mouth of Five Springs Creek.	Warm	?	Cretaceous sediments	Several springs. Water used locally. Refs. 18, 59.
3	T.53N., R.94W., near upper end of Black Canyon (Wyoming) of the Big Horn River.	Warm	Small	Paleozoic sediments	Refs. 18, 59.
4	Flagg Ranch Hot Springs (later called Huckleberry Hot Springs). Sec. 20, T.48N., R.115W.	Many boiling	100-800	Pleistocene rhyolite	Refs. 1, 40, 46, 53, 59.
5	Astoria Springs. Sec. 32, T.39N., R.116W.	34-40 (main pool)	100	Permian sediments	Hot baths. Refs. 40, 59.
6	Granite Hot Springs.	41-43	360 or larger	Flathead sandstone (Cambrian), near granite	Several Springs. Refs. 40, 59.
7	Auburn Hot Springs. 2.5 miles north of Auburn, Wyoming.	20-62	38	Faulted Phosphoria Fm. (Permian)	Many springs. H ₂ S smell, salty taste. Bubbling at some springs. Sulfur and salt deposits nearby and in neighboring subsurface section. Travertine de- posits. Refs. 42, 46, 51.
8	Kendall Warm Springs. Sec. 2, T.38N., R.110W. on Green River near Wells, Wyoming.	Warm	>850	Phosphoria Fm. (Permian)	Six springs. Refs. 40, 59.
9	Steele Hot Springs. T.32N., R.107W., near Fremont Butte.	Hot	Small	Precambrian granite	Water used for bathing. Refs. 29, 35, 59.
10	Near Warm Spring Creek, four miles northwest of Dubois, Wyoming.	29 (Max)	?	Phosphoria Fm. (Permian)	Several springs. Deposits of travertine. Refs. 21, 30, 46, 50, 57, 59.
11	Near mouth of Little Warm Spring Creek, three miles south- west of Dubois.	20	?	Phosphoria Fm. (Permian)	Several springs. Deposits of travertine. Refs. 21, 46, 57, 59.
12	Firt Washakie Hot Springs. Sec. 2, T.1S., R.1W., 24 miles west of Riverton	43+	2,000	Chugwater Fm. Red Peak Member (Triassic)	Several springs, rising in deep pools. Refs. 1, 8, 16, 17, 20, 31, 32, 46, 54, 59.
13	T.30N., R.97W., four miles southwest of Hailey	38-49	100	Chugwater Fm. (Permian & Triassic)	Several springs. Water smells of H ₂ S. Used for irrigation. Ref. 59.
14	T.29N., R.96W., near Sweetwater River, 12 miles southwest of Myersville	Warm	?	Sandstone (Oligocene)	Several springs. Water used locally. Ref. 59.

15	Big Horn (Thermopolis) Hot Springs, on the Big Horn River at Thermopolis.	57	12,600	Tensleep Sandstone (Pennsylvanian and Permian)	One large spring and several small springs. Large deposit of tufa. Travertine deposits. Ref. 59.
16	Three and one-half miles northwest of Thermopolis, near sulfur deposits.	Hot	Small	Red Beds (Triassic)	Deposits of tufa and sulfur. Flow formerly much greater. Ref. 59.
17	Sec. 35, T.32N., R.86W., on Horse Creek near Independence.	Warm	Large	Oligocene strata near Chugwater Fm. (Permian and Triassic)	Several springs. Water used locally. Ref. 59.
18	Alcova Hot Springs, T.30N., R.83W., in Fremont Canyon of the North Platte River.	59	75	Faulted Upper Cretaceous strata	Several springs. Resort. Ref. 59.
19	Sec. 8, T.31N., R.71W., near the North Platte River, nine miles south of Douglas.	Warm	?	Triassic and Permian sediments, undivided (includes Chugwater Fm.)	Water used for bathing and irrigation. Refs. 1, 59.
20	Saratoga Hot Springs. T.17N., R.84W.	48-53	10-120	North Park Fm. (Late Miocene)	Resort. Several springs. Refs. 1, 41, 45, 46.
21	Guernsey Hot Springs (?) Sec. 4, T.26N., R.66W.	23+	?	Hartville Fm. (Pennsylvanian)	Refs. 4, 5, 43.
22	Jackson Lake Hot Springs. Sec. 7, T.46N., R.115W.	50 (Max)	?	Madison Limestone (Mississippian)	Thirteen orifices visible above lake level at low water. Ref. 40.
23	Kelly Warm Spring. Sec. 2, T.42N., R.115W.	30 (Max)	> 3400	Pliocene tuff and lake sediments	Ref. 40.
24	Abercrombie Warm Spring. Sec. 2, T.41N., R.116W.	?	?	Fault between Ordovician and Pliocene	Ref. 40.
25	Teton Valley Warm Spring. Sec. 1, T.42N., R.115W.	23- (Max)	> 6900	Madison Limestone (Mississippian)	Ref. 40.
26	School Section Spring. Sec. 36, T.41N., R.117W.	31+	N/A	Thrust fault between Cambrian and Upper Cretaceous	Flows six inch pipe of water. Ref. 40.
27	Bradco-Gilcrease Well. Sec. 25, T.39N., R.116W.	48-	N/A	Triassic sediments	Six inch pipe flows 48°C water from depth of 3065 ft. Ref. 40.
28	Dallas Well. T.33N., R.99W.	38-43	N/A	Madison Limestone (Mississippian)	Eight inch pipe flows 38-43°C water. Ref. 40.
29	Carter Cole Well (Carter Oil Co.) T.33N., R.68W.	135	N/A	Lower Cretaceous sediments (50% shale, 50% sandstone)	Bottom-hole temperature at 11,000 ft. Ref. 40.
30	Fremont Petroleum Co. Well. T.52N., R.101W.	69-	N/A	Tensleep Sandstone (Pennsylvanian)	Bottom-hole temperature at 1476 ft. (Flowing water). Ref. 40.
31	SW $\frac{1}{4}$, Sec. 20, T.28N., R.118W.	Warm(?)	8000(?)	Mesozoic and Paleozoic strata	Several cold springs, one warm. Several travertine deposits. Ref. 25.

CURSORY EVALUATION OF AREAS OUTSIDE YELLOWSTONE PARK

Godwin *et al.* (1971) briefly discuss the factors that may be employed in the evaluation of geothermal resource areas. The application of some of these criteria to areas in Wyoming outside Yellowstone Park is briefly summarized below:

—None of the springs listed in Table 1 are characterized by geyser activity. In addition, there is little evidence for significant amounts of siliceous sinter at each locality, while several of the areas are characterized by large deposits of calciferous sinter (travertine) (see Table 1). For the springs with a large discharge, these data imply low reservoir temperatures (Godwin *et al.*, 1971; White, 1970).

—The analyses listed in Table 2 were discussed with J.I. Drever and H.P. Eugster, geochemists at the University of Wyoming. My impressions of their comments are: (a) the compositions are not inconsistent with low-temperature (100°C) reactions between meteoric waters and marine sediments or volcanic rocks; and (b) although the compositions may not be employed for accurate geothermometry, they may imply

that reservoir temperatures are not abnormally high. White (1970) infers that the SiO₂ content of sample #2 from Thermopolis Hot Springs (Table 2) also implies low temperature (115°C) in the underlying reservoir.

—Several of the springs are characterized by moderate temperatures (total measured range 23.3° - 62.2°C). Although surface data may provide estimates for minimum subsurface temperature, those springs with maximum temperatures of 23° to 29°C could reflect the result of waters circulating (to depths of one to two kilometers in areas with normal geothermal gradients (approximately 25°C/km). Other data in Wyoming suggest that some of the other springs are not associated with shallow "geothermal reservoirs." For example, heat flow determinations at Cooke City and Nye Basin, Montana and Meeteetse, Wyoming range from 1.3 to 1.8 HFU* (Blackwell, 1969; Sass *et al.*, 1971), suggesting that the

*1 HFU = 1 heat flow unit = 1 microcal/cm² sec.

TABLE 2: RECENT CHEMICAL ANALYSES OF WATER FROM THERMAL SPRINGS IN WYOMING (excluding Yellowstone National Park)

	pH	SiO ₂	Fe	Ca	Mg	Na	K	HCO ₃	SO ₄	Cl	F	NO ₃	B
	(parts/million)												
DeMaris (Cody)													
Hot Springs													
WRL-429(a)	6.9	18.0	.06	354.0	72.0	33.0	16.0	952.0	422.0	21.0	2.0	.1	-
WRL-430(a)	7.1	18.0	.20	369.0	63.0	33.0	16.0	993.0	418.0	20.0	2.0	.1	-
Saratoga													
Hot Springs													
(Hobo Pool)(b)	7.3	62.0	-	125.0	9.0	453.0	29.0	77.0	568.0	511.0	6.5	6.5	.1
Thermopolis													
Hot Springs													
Sample 1(b)	-	82.0	.08	385.0	76.0	262.0	49.0	766.0	769.0	328.0	3.7	.1	-
Sample 2(c)	6.2	36.0	.04	374.0	74.0	271.0	44.0	756.0	726.0	320.0	3.5	-	7.8

References: (a) J. D. Love (personal communication, 1972); (b) Open file, Wyoming Geological Survey;

(c) White, *et al.* (1963).

anomalous regional flux (6-10 HFU; after White, 1965; Marler, 1969) in Yellowstone Park does not extend very far to the east and northeast. Considered together, the geothermal data in the Absaroka region (Fig. 2) suggest that the DeMaris Hot Springs may be related, in part, to above average, but not abnormal regional flux and gradients. The high gradients in areas around Thermopolis, Alcova, and the Rattlesnake Hills (Fig. 2) suggest that 60° to 70°C waters could occur between one and two kilometer depths near these springs while the regional flux may not be abnormally high (see Blackwell, 1969).

—The high bottom-hole temperature (135°C) in the Carter Cole well, the thermal springs near Douglas and Blackwell's (1969) "estimated" heat flows (1.8 to 2.0 HFU) in the Salt Creek and Lance Creek oil fields, suggest that the Powder River Basin may be characterized by above average flux. This zone of high flux (?) may extend northeast as far as the Black Hills; Blackwell (1969) and Sass *et al.* (1971) calculated heat flows of 1.9 HFU near Lead, South Dakota, and recent

studies (Decker, unpublished) west of Spearfish tend to confirm high regional flux (1.9 - 2.4 HFU). These values of flux are not high enough to suggest shallow geothermal reservoirs, but above average heat flow would imply that the Basin could be a source of hot waters

In summary, the available data imply that some of the thermal areas in Wyoming, outside of Yellowstone National Park, are not characterized by reservoir temperatures appropriate for the development of steam directly as a result of shallow (2 km) drilling. However, the present information on every area is inadequate for proper evaluation. Therefore, more rigorous geochemical, geophysical and geological studies should be initiated at each locality. A better knowledge of the heat flow pattern in eastern Wyoming is also needed, since water demand in the Powder River Basin is expected to greatly increase by the year 2000 (report, Cameron Engineers, 1969). Although geothermal steam may not be a major resource, the many uses of hot water should be considered in the future development of the state.

PRESENT ELECTRIC POWER AND FUTURE DEMANDS

The following information on the present supply and future demands for power in the State of Wyoming was abstracted from a report by the Governor's Electric Power

Advisory Committee (1971), the Cameron Engineers Report (1969) and updated with 1976 Geological Survey of Wyoming data.

PRESENT GENERATION CAPACITY AND SHORT TERM DEMAND

As of January 1976, the total capacity of all installed electric power plants in Wyoming was 2753 megawatts (Table 3). Eight percent of this power was produced at eleven hydroelectric generating dams located in the main river drainages. The remaining 92 percent of the power was supplied by coal-fired thermal generating plants located in or near the major coal-producing areas. By 1983 the peak generating capacity will increase 246 percent to 6783 megawatts.

Electrical consumption in Wyoming has increased from 3.4 million megawatt hours in 1970 to 4.6 million megawatt hours in 1974 (Table 4). By 1980 the predicted state requirements are 7.4 million megawatt hours. The portion of state generated power con-

sumed in the state for this ten year period will drop from 54 to 27 percent. Seventy three percent of the power generated will be exported.

The 1980 demand for the individual sectors by private utilities, municipalities, R.E.A. cooperatives and others in Wyoming may be briefly summarized as follows (report, Governor's Electric Power Advisory Committee, 1971):

1. *Private electric utilities*—By 1980 the peak demand for private companies is estimated to be about 883 megawatts, an increase of 95% over 1971. Planned additions of coal-fired thermally generated power will far exceed the needs in Wyoming.

2. *Municipalities*—The peak demand for municipalities should increase by about 74 percent by 1980, or from 15.74 megawatts to 27.37 megawatts. The indications are that power supply from the United States Bureau of Reclamation will be inadequate by this time.
3. *R.E.A. cooperatives and others*—The

estimated peak demand for cooperatives and others should be about 342 megawatts by 1980, an increase of about 90 percent over the 1971 supply. Figures indicate that the present government-owned generating capacity in Wyoming will not be adequate to supply the demand.

TABLE 3: INSTALLED PEAK CAPACITY OF WYOMING ELECTRIC UTILITY GENERATING PLANTS

<u>Hydroelectric Plants</u>	<u>1976-- megawatts</u>	<u>1983 - megawatts</u>
Shoshone	5.6	
Pilot Butte	1.6	
Guernsey	4.8	
Seminole	32.4	
Hart Mountain	5.0	
Kortes	36.0	SAME
Boysen	15.0	
Alcova	36.0	
Glendo	24.0	
Fremont Canyon	48.0	
Fontenelle	10.0	
Total Hydroelectric	218.4	218.4
<u>Thermal Generation -- Coal</u>		
Acme (1 unit)	12	(close 1976?)
Jim Bridger (2 units)	1000	(4 units) 2000
Dave Johnston (4 units)	750	(4 units) 750
Naughton (3 units)	710	(5 units) 1450+
Osage (3 units)	35	(3 units) 35
Neil Simpson (5 units)	28;	replaced by Wyodak, 330
		Laramie River Station (4 units) 2000
Total Coal	2535	6565
<u>Total Hydroelectric & Thermal</u>	2753*	6783

* An additional peak capacity of 12MW is generated only intermittently by Cheyenne LF&P and Pinedale P&L.

Sources: Governor's Electric Power Advisory Committee (1971) and Geological Survey of Wyoming updated (1976) figures

LONG TERM DEMANDS

Because of the small projected growth (+2%) in population, the limited local marketing for products and the lack of manufacturing industry, it is generally thought that Wyoming's long-range requirements for energy will be dominated by the needs of mineral industries (report, Cameron Engineers, 1969). The major requirements of these industries will be water and electrical power. For example, demand for water is expected

to increase from 91,000 acre feet to 850,000 acre feet by the year 2020 (report, Cameron Engineers, 1969). The estimated demand for electrical power also shows a nine to ten fold increase over the same interval. The increase in demand for electrical power is expected to be supplied by large-capacity, coal-fueled generators using coal from Wyoming.

TABLE 4: WYOMING ELECTRICAL CONSUMPTION AND EXPORT

YEAR	Millions of Megawatts		Percent Consumed	
	Net	Wyoming	Wyoming	Out of State
1970	6.3	3.4	54%	46%
1971	6.2	4.0	65	35
1972	8.1	4.0	50	50
1973	10.2	4.3	42	58
1974	9.7	4.6	47	53
1975*	---	---	--	--
1976*	---	---	--	--
1977	17.8	6.0	34	66
1980	27.8	7.4	27	73

*Figures unavailable

After: Wyoming Energy Consumption -- Minerals, Fuels, Electrical Generation and Agricultural Sectors: a report by Bickert, Brown, Coddington & Associates, Inc. (June, 1975).

TABLE 5: PAST AND ESTIMATED FUTURE ELECTRICAL POWER REQUIREMENTS OF THE MINERAL INDUSTRIES IN WYOMING (After a report by Cameron Engineers, 1969).

YEAR	Requirement
	<u>10⁶ Kilowatt Hours</u> YEAR
1967	780
1972	1050
1980	2700
2000	5400
2020	7400

STATE LAWS AND AGENCIES

Wyoming has legislation which directly bears on exploration in the vicinity of thermal springs. One law reserves the total flow of the Big Horn Hot Springs (Thermopolis) for the state (Wyoming Statutes, Sec. 36-160.1 suppl. 1971). The others refer to thermal springs in general, and are reproduced below (Wyoming Statutes, Secs. 41-1.9 through 41-1.11 suppl. 1971):

1. The State Engineer is given the authority to abolish, correct, discontinue or stop any condition which interferes with the natural flow of any thermal spring which is located on state lands.
2. Nothing in this Act shall be construed to limit any nonthermal water or mineral development so long as said development does not interfere with

the natural flow of the thermal springs covered herein.

3. The State Engineer may seek injunctive relief to implement these provisions.

It should be mentioned that all waters in Wyoming are considered to be the property of the State. Therefore there are state laws requiring drilling permits for the development of water (Wyoming Statutes, Secs. 41-121 through 41-147, 1957; suppl. 1971) and the proper "plugging" of holes that intercept water (Wyoming Statutes, Secs. 30-96.14 through 30-96.21, suppl. 1971). Enforcement of these laws is handled by the State Engineer.

A complete compilation of geothermal permit rules for Wyoming is included in Appendix I.

APPENDIX I

RULES AND REGULATIONS GOVERNING THE ISSUANCE OF GEOTHERMAL RESOURCE PERMITS AND LEASES

Section 1. Character and Extent of Lands.

a. Lands subject to lease are those within a known geothermal resources area. The application shall be for a reasonably compact area not less than 640 acres nor more than 2,560 acres. A permit or lease may be issued for a parcel less than 640 acres if such parcel is isolated from or not contiguous with other parcels of state land available for permit or lease.

b. Lands subject to prospecting permits are those not lying within a known geothermal resources area.

c. The State Board of Land Commissioners may include in its lease offer, areas adjacent to that for which application has been made, should it determine that such additional land lies within a known geothermal resources area.

Section 2. Duration of Permits and Leases.

a. Prospecting permits are limited to a period not exceeding three years, extendable for a period of an additional two years at the discretion of the Board, provided that the combination of the primary term and extension shall not exceed a total of five years.

b. Leases shall be issued for a primary term of 10 years, and so long thereafter as geothermal resources are being produced or utilized or are capable of being produced or utilized in commercial quantities from such lands or from such lands unitized therewith.

Section 3. Who May Apply for a Geothermal Resources Permit and Lease.

Any United States citizen of legal age, or any firm, association or corporation which is qualified to do business in the State of Wyoming, and is not in default under the laws of the State of Wyoming, relative to qualifications to do business within this State, and governmental units, including without limitation, municipalities shall be qualified to lease the Geothermal Resources in State land;

provided, that no member of the State Board of Land Commissioners or employee of the Department of the Commissioner of Public Lands may take or hold such lease or any interest therein. Provided further that said person, firm, association or corporation must have physical and financial capability to develop the geothermal resource sought, and is not merely a speculative broker.

Section 4. Prospecting Permit and Lease Procedures.

a. Any person qualified under Section 1. may apply for a prospecting permit by filing with the Commissioner of Public Lands a written application containing the following:

(1) Name, address, and status of citizenship of applicant; if applicant is a corporate name and name of president, secretary, and officer or persons authorized to execute contracts and leases.

(2) A description of the state lands involved.

(3) A statement of the use proposed.

(4) A statement of the character and use of adjoining lands.

(5) A statement of the methods proposed to be used in developing the resource.

(6) A statement of the quality and use of underlying groundwaters and adjacent surface waters.

(7) A statement of proposed liquid, solid, or gaseous waste disposal methods necessary for the protection and preservation of existing land and water uses.

(8) A statement describing any and all state geothermal leases in which the applicant has any direct or indirect interest.

(9) A statement that the applicant has the present physical and financial capability to develop the geothermal resource.

b. The application shall be accompanied by a filing fee of \$15.00, and a rental deposit equal to the first year's rental in the amount of \$1.00 per acre per year for each acre or fraction thereof within the desired permit area.

c. Permit forms shall be provided by the Commissioner of Public Lands for the applicant's acknowledged or witnessed execution and shall then be presented to the Board for its approval.

d. The Board shall grant a permit to a qualified applicant whose application is first filed in the offices of the Commissioner of Public Lands. The Board expressly reserves the right to issue a permit to a person, association or corporation other than a first applicant when it appears to the Board that said person, association or corporation, by virtue of ownership of the right to explore and develop Geothermal Resources in lands adjacent to State Lands, is unusually likely to explore and develop the Geothermal Resources in the State Lands.

Section 5. Filing Fees.

The application for a Geothermal Resources Permit shall be accompanied by a filing fee of \$15.00. Failure to deposit a sufficient filing fee shall constitute a defect in the Permit and the application will not be considered properly filed until the correct filing fee is paid.

Section 6. Work Requirements.

Permittee shall conduct prospecting work to determine the geothermal resources character of the land under permit. Such prospecting work may include geological, geophysical, geothermal and geochemical work and other operations. Data obtained from such prospecting work shall be made available to the Office of the State Engineer for their confidential use and may not be released to any other person or agency without the permittee's written authorization. Work performed outside the permit area may be used to satisfy the work requirement if, in the judgment of the Board of Land Commissioners, it determines the geothermal character of the land.

Section 7. Time of Filing.

Applications for Geothermal Resources

Permits, except in the case of simultaneous filing, will be received for filing in the office of the Commissioner of Public Lands during office hours. Except as hereinafter expressly provided, all such applications received, whether by U.S. mail or by personal delivery over the counter, shall be immediately stamped with the exact time and date of receipt. The date indicated on the time stamp shall be deemed the date of filing unless the Commissioner shall determine that the application is deficient in any particular or particulars.

Section 8. Simultaneous Filing.

Except as otherwise provided herein, applications for permits to prospect for Geothermal Resources shall be considered in the order in which they are filed. The Board shall have the authority to withdraw any State Lands from permit application at any time prior to the approval by the Board of a permit application; or to declare the State Lands as being within a known Geothermal Resources area and subject to competitive bidding. But unless State Lands are withdrawn and except as otherwise provided herein, the Board shall issue a permit for the land to the first qualified applicant who has filed an application in accordance with rules and regulations promulgated by the Board.

Except as otherwise provided herein, in all cases where lands become available for permit application by the Board because they are newly acquired, or because an existing Geothermal Resources lease is cancelled, relinquished, surrendered, or for any reason terminated, the Board shall offer the land for subsequent Geothermal Resources permit application by the following procedures:

a. A notice of the lands having so become available for permit application shall be posted in the offices of the Commissioner of Public Lands. The notice shall describe the land, indicate that the Geothermal Resources in each tract is available for permit application and state the last date, which shall be at least thirty (30) days after the notice is posted, on which applications will be received.

b. Except as provided in Subsection (c), all applications filed before the closing date stated in the notice shall be considered to have been filed simultaneously. Such applications shall be submitted in sealed envelopes

marked for simultaneous filing, and shall be opened in the office of the Commissioner of Public Lands at 10:00 o'clock on the morning of the first business day following the last day on which applications are receivable. The Board of Land Commissioners shall award permits to responsible qualified applicants by public drawing at the office of the Commissioner of Public Lands.

c. The applications for simultaneous filings shall be on a form supplied by the Commissioner of Public Lands and shall be accompanied by a separate check for the filing fee and a separate check for the rental required, and a self-addressed, stamped return envelope.

d. Following the results of the public drawing and the awarding of the permits to the successful applicants, all checks except the filing fee checks tendered by the unsuccessful applicants shall be returned together with a list of the successful applicants.

Section 9. Preferential Lease Procedures.

Upon classification of any land within the permit area as being known geothermal resources land, permittee shall be entitled to a preferential lease for such land, providing permittee submits his application for a lease for such land within ninety (90) days after being notified of the classification, establishes his qualifications, and completes said application with due diligence. Unless permittee does so, his right to a preferential lease shall terminate.

Section 10. Bidding Procedures.

Lands lying within a known geothermal resources area, not subject to a preferential lease under a prospecting permit, may be leased pursuant to a published notice of intention to receive bids. Terms of bidding procedures shall be determined by the Board and specified by published notice.

Section 11. Development Program.

a. Operations under any lease or permit shall be carried on in a safe and workmanlike manner in accordance with generally accepted good engineering practice and due regard shall be given the protection of life and property, preservation of the environment and the conservation of natural resources.

b. No lessee or permittee shall drill a geothermal resources well on or into state lands except on prior approval of the State Engineer and subject to the terms of the lease or permit.

c. Lessee or permittee, before commencing the work of drilling a well, shall obtain a permit from the State Engineer, and such notice shall contain the location and elevation above sea level of derrick, proposed depth, bottom hole location, casing program, proposed completion program and the size and shape of drilling site, excavation and grading planned, and location of existing and proposed access roads.

d. The Board, upon recommendation from the State Engineer, may determine the spacing of wells and the rate of development and production of such wells to prevent the waste of geothermal resources and to promote their maximum economic recovery from, and the conservation of reservoir energy in, each zone or separate underground source of geothermal resources. Such determination shall be based on recognized engineering standards and shall be consistent with prevailing economic conditions.

e. Upon request, the State Engineer will be furnished individual well data necessary to determine that field development is based on sound engineering practices.

f. Geothermal resources shall not be disposed of except in accordance with sales contracts or other methods which have first been approved of in writing by the State Engineer.

g. All drilling, re-drilling, perforating, or work-over operations within any geothermal resources zone shall be done with a safe and acceptable circulating medium.

h. No well shall be perforated, re-drilled, plugged back, or altered except on prior approval of the State Engineer.

i. Metering equipment shall be maintained and operated in such a manner as to meet acceptable standards of accuracy. Upon determination by the State Engineer that standards of accuracy or quality are not being maintained, Lessee shall bring metering equipment accuracy and quality to acceptable standards as quickly as reasonably possible.

j. No generating plants, buildings, structures, production equipment, metering systems, pipelines or roads for the production of geothermal resources shall be installed except on prior approval of the Board upon recommendation of the State Engineer. Any material or significant changes in said equipment or facilities shall be approved prior thereto. Maps, drawings and specifications for said installations shall be furnished upon request.

k. Lessee shall diligently maintain all wells to prevent waste of geothermal resources.

l. Before work is commenced to abandon any well, notice shall be given to and approved by the State Engineer, which notice shall show the condition of the well and the proposed method of abandonment. No well may be abandoned unless prior approval of the method of abandonment has been obtained from the State Engineer.

Section 12. Rentals and Royalties.

Geothermal Resources leases shall be issued for an annual rental of Two Dollars (\$2.00) per acre or fractional part thereof, payable in advance. Second year and subsequent rental due dates shall be on or before the anniversary of the effective date of a lease. The effective date of a lease is the first day of the month in which the lease is issued.

The annual rental for the first year shall be due and payable upon filing of the application. The Commissioner of Public Lands will notify the applicant or his representative designated in the application to lease by mail of the Board's approval. Failure to pay sufficient rental shall constitute grounds for immediate cancellation of the lease.

After Geothermal Resources are produced from the premises, a lessee must pay or tender payment of royalties not later than the 25th day of the calendar month following the calendar month of production.

Royalty payments shall consist of:

a. Ten percent (10%) of the gross revenue as determined by a reasonable value received exclusive of charges, approved by the Board, made or incurred with respect to transmission or other services or processes, received from the sale of steam, brines, from which no minerals have been extracted, and associated gases

at the point of delivery to the purchaser thereof.

b. A royalty of Five percent (5%) of the gross revenue, exclusive of charges, approved by the Board, that were made or incurred with respect to transmission or other services or processes, received from the sale of mineral products or chemical compounds recovered from geothermal fluids or chemical compounds.

All royalties shall be subject to renegotiation after Ten (10) years from the effective date of a lease and at Ten (10) year intervals thereafter and such renegotiations shall not be limited by the maximum royalties specified in subdivision (a) and (b).

Royalty payments shall be made pursuant to the provisions of subdivisions (a) and (b) for all Geothermal Resources used by a lessee and not sold, with the gross revenue therefrom to be determined as though such Geothermal Resources had been sold to a third person at the then prevailing market price in the same market area and under the same marketing conditions. No royalties shall be payable for steam or hot water used by a lessee in the production of any geothermal mineral products or chemical compounds recovered from fluids in first marketable form subject to the payment of royalties under subdivisions (a) and (b).

Section 13. Refunds and Withdrawals.

a. If an application for a Geothermal Resources lease is rejected, all checks tendered by applicant, except the filing fee, will be returned.

b. Should an applicant desire to withdraw his application, all checks tendered by the applicant, will be retained as earned. If the request is received after approval, then, unless the applicant accepts the offered lease, all money tendered is forfeited to the State, unless otherwise ordered by the Board for good cause shown.

Section 14. General Provisions.

a. Except in the instance of non-payment of rentals or royalties, upon violation by a lessee of any provision in the law, any provision in a Geothermal Resources lease or any regulation promulgated by the Board, the

Board may, at its option, cancel the lease after sixty (60) days' notice by registered or certified return receipt mail, unless the lessee remedies the violation or rectifies the condition within said sixty (60) days or within such extension of time as the Board may grant.

b. It is the policy of the State of Wyoming to foster and promote multiple use and development of State lands. Each lessee under a State of Wyoming Geothermal Resources permit or lease shall conduct operations in such manner as to avoid unreasonable and all unnecessary damage or injury to State Lands and improvements belonging to others including those belonging to the State of Wyoming.

c. The term of all Geothermal Resources leases included in any co-operative or unit plan of Geothermal Resources development or operation in which the Board has joined or shall hereafter join, shall be extended automatically for the term of such unit or co-operative agreement. Rentals or minimum royalties on leases so extended shall be at the rate specified in the lease. The Board may with the consent of its lessees modify and change any and all terms of leases issued by it to facilitate efficiency and resource conservation in Geothermal Resources operations in State Lands.

d. Any lease which shall be eliminated from any such co-operative or unit plan of development or operation, or any lease which shall be in effect at the termination of any such co-operative or unit plan of development or operation, unless relinquished, shall continue in effect for the fixed term of the lease or for two years after its elimination from the plan or agreement or the termination hereof, whichever is longer, and so long thereafter as Geothermal Resources are produced in paying quantities.

Section 15. Bond Requirements.

a. Upon delivery of the executed Geothermal Resources lease to the Board, the lessee must upon commencement of operation, furnish a good and sufficient bond in the amount of \$5,000.00 in favor of the State of Wyoming conditioned on the payment of all damages to the surface and all improvements including without limitation crops on the lands, whether or not the lands under this lease have been sold or leased by lessor for

any other purpose; conditioned also upon the faithful performance of lessee's obligations under this lease and the rules and regulations of the lessor. Lessee may furnish a statewide bond in amount of \$50,000.00 to cover all operations on State leases.

Section 16. Assignments and Sub-leases or Mineral Leases and Overriding Royalties.

It is the express policy of the State of Wyoming to insure that all benefits derived from the State's Geothermal Resources inure to the people of the State. For this reason no geothermal permit or lease may be assigned, sublet or otherwise transferred for any reason whatsoever without written permission of the Board. The express reason for this provision is to prohibit any person from speculating with said permits and leases for personal gain other than by honestly and forthrightly developing the geothermal resources itself.

Section 17. Unit or Cooperative Plans of Development.

Lessees under Geothermal Resources leases issued by the Board are authorized, with the consent of the Board, to commit the State lands to unit, co-operative or other plans of development with other State Lands, federal lands, privately owned lands, or Indian Lands; and to implement such unitization, the Board is authorized with the consent of its Geothermal Resources lessees to modify and change any and all terms of leases issued by it which are committed to such unit, co-operative or other plans of development.

The Commissioner is authorized, when separate tracts under lease cannot be independently developed and operated in conformity with an established well-spacing or well-development program, to approve, or to require lessees to enter into, communitization or drilling agreements providing for the apportionment of production or royalties among the separate tracts of land comprising the drilling or spacing unit for the lease, or any portion thereof, with other lands, whether or not owned by the State of Wyoming, when in the public interest. Operations or production pursuant to such an agreement shall be deemed to be operations or production as to each lease committed thereto.

Before issuance of a geothermal lease for lands within an approved unit agreement, the lease applicant or successful bidder will be required to file evidence that he has entered into an agreement with the unit operator for the development and operation of the lands in a lease if issued to him under and pursuant to the terms and provisions of the approved unit agreement, or a statement giving satisfactory reasons for the failure to enter into such agreement. If such statement is acceptable, he will be permitted to operate independently, but will be required to perform his operations in a manner which the State Engineer deems to be consistent with the unit operations.

Section 18. Confidential Information.

Upon request by the lessee or operator all logs, reports, maps or histories required to be furnished to the Board or to the Wyoming Department of Public Lands under the provisions of any Geothermal Resources lease or other agreement will be held confidential for a period of Five (5) years from well completion with an additional Two (2) year extension, upon application unless released for public information by the lessee before that time.

Any experimental logs, tests, or interpretative data not generally available to all operators shall be held confidential for Ten (10) years from well completion, unless approved for release earlier by Lessee or Operator. Experimental logs shall mean those logs which are so newly developed or so limited or specialized in application that they are not commonly run on geothermal wells.

Section 19. Right of Cancellation by Board.

The Board reserves the right to cancel any Geothermal Resources permit or lease upon failure by the lessee to exercise due diligence or care in the prosecution of his operations in accordance with the terms and conditions stated in the permit or lease, and these rules and regulations.

Section 20. Commingled Production.

Geothermal resources from any two or more wells, regardless of whether such wells are located on state land, may be commingled when the metering system used to measure geothermal resources has been approved by

the State Engineer. Prior to the installation of the metering system, lessee or permittee shall submit for approval a schematic drawing of the proposed system and specifications of the major equipment components. The State Engineer will determine if acceptable standards of accuracy for measuring geothermal resources have been obtained, and may approve commingling of geothermal resources. The metering equipment shall be maintained and operated in such a manner as to meet acceptable standards of accuracy. Upon determination by the State Engineer that standards of accuracy or quality are not being maintained, Lessee shall bring metering equipment accuracy and quality to acceptable standards as quickly as reasonably possible.

In the event that the quality and composition of the geothermal resources to be commingled are substantially different, it shall not be approved by the State Engineer until acceptable standards and methods of payment are established.

Section 21. Protection of Other Resources.

a. The lessee or permittee shall remove the derrick and other equipment and facilities within sixty (60) days after lessee or permittee has ceased making use thereof in its operations.

b. All permanent operating sites where required shall be landscaped or fenced so as to screen them from public view as far as possible. Such landscaping or fencing shall be approved in advance by the State Engineer and kept in good condition.

c. All drilling and production operations shall be conducted in such manner as to eliminate as far as practicable dust, noise, vibration, or noxious odors. Operating sites shall be kept neat, clean and safe.

d. Wastes shall be discharged in accordance with requirements and Prohibitions prescribed by the Department of Environmental Quality (Water Control Board) which shall also approve the place and manner of such waste disposal.

e. Lessee or permittee shall communicate with the Department of Game and Fish prior to any operations which may adversely affect fish and wildlife resources.

f. Any operations disturbing the soil surface, including road building, construction, and movement of heavy equipment in support of or relating to specific geothermal exploration or development activities shall be conducted in such manner as will not result in unreasonable damage to trees and plant cover, soil erosion, or in degradation of waters of the State, including fish and aquatic life habitat.

g. Existing roads and bridges on or serving the area under lease or permit shall be maintained in a condition equal to or better than that before use. New roads and bridges shall be located, constructed, and maintained in accordance with state specifications.

h. Timber damaged, destroyed, or used on the area under lease or permit shall be compensated for at market value to the state. Borrow pit material shall not be obtained from state lands without permission and payment of market value.

i. Improvements, structures, telephone lines, trails, ditches, pipelines, water developments, fences and other property of the state or other lessees or permittees, and permanent improvements and crops of surface owners, shall be protected from damage and repaired or replaced when damaged.

j. Access to drilling or production sites by the public shall be controlled by the lessee or permittee to prevent accidents or injury to persons or property.

k. Drilling mud shall be ponded in a safe manner and place, and where required by the state, posted with danger signs, and fenced to protect persons, domestic animals, and wildlife. Upon completion of drilling, the mud shall be disposed of, or after drying in place, covered with a protective layer of soil.

l. Areas cleared and graded for drilling and production facility sites shall be kept to a reasonable number and size, and be subject to state approval.

m. Lessee or permittee shall conduct its operations in a manner which will not interfere with the right of the public to fish upon and from the public lands of the state and in the waters thereof or will not preclude the right of the public to use of public lands and waters.

Section 22. Indemnification.

Lessee or permittee agrees to indemnify and save harmless the State of Wyoming, its officers, agents and employees against any and all claims, demands, causes of action, or liability of any kind which may be asserted against or imposed upon the State or any of its officers, agents, or employees by any third person, or entity arising out of or connected with the issuance of the lease or permit, operations hereunder, or the use by lessee or permittee or its agents, employees or contractors of the land. Without limiting the generality of the foregoing, such indemnification shall include any claim, demand, cause of action or liability of any kind asserted against or imposed upon the State or any of its officers, agents or employees arising out of or connected with any alleged or actual violation by lessee or permittee, its agents, employees or contractors of property or contractual rights of any third person or entity. At the option of the Board, lessee or permittee shall procure and maintain liability insurance for the benefit of the state in an amount satisfactory to the Board.

Section 23. Records and Reports.

Lessee or permittee shall furnish to the Commissioner of Public Lands for its confidential use the following in the manner and form prescribed:

a. Statements showing the work performed upon the leased or permitted area and the amount, quality, and value of all geothermal resources produced, shipped or sold.

b. Copies of all physical and factual exploration results, logs and surveys which may be conducted, well test data, and other data resulting from operations under the lease or permit.

Section 24. Suspension of Operations.

In the event of any disaster or of pollution caused in any manner or resulting from operations under a lease or permit, lessee or permittee shall suspend any drilling and production operations, except those which are corrective, or mitigative, and immediately and promptly notify the State Engineer. Such drilling and production operations shall not be resumed until adequate corrective measures have been taken and authorization for

resumption of operations has been made by the State Engineer. The lessee or permittee shall suspend any drilling and production operations, except those which are corrective or mitigative, if the State Engineer with the concurrence of the Department of Environmental Quality shall determine that there is a substantial likelihood that continued operations would endanger public health or safety or cause serious damage to property or the natural environment. Such operations shall not be resumed until the State Engineer shall determine that adequate corrective measures are feasible and have been taken to eliminate such substantial likelihood.

Section 25. Surrender of Premises.

At the expiration of the lease or permit, or sooner termination thereof, lessee or permittee shall restore the lands covered by said lease or permit to their original condition insofar as it is reasonable to do so, except for such roads, excavations, alterations or other improvements which may be designated for retention by the Board. Where determined

necessary by the Board, cleared sites and roadways shall be planted with grass, shrubs or trees.

Section 26. Shut-in Well Clause.

If a well capable of producing Geothermal Resources located on the Premises or on acreage combined therewith is at any time shut-in and no Geothermal Resources therefrom are sold or used by Lessee off the Premises or processed by Lessee or used by Lessee for the manufacture of other products, such shut-in well shall be deemed to be a well producing Geothermal Resources from the Premises and this lease will continue in force during all of the time or times while such well is so shut-in, whether before or after the expiration of the primary term hereof. Lessee shall use reasonable diligence to market Geothermal Resources capable of being produced from such shut-in well, but shall be under no obligation to market such Geothermal Resources under terms, conditions or circumstances which, in Lessee's judgment exercised in good faith, are unsatisfactory.

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OFFICES WITH OTHER INFORMATION ON
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