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A HYDROGEOCHEMICAL STUDY OF THE THERMAL WATERS OF ALCOVA, SARATOGA, AND DOUGLAS, WYOMING

by

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INTRODUCTION

Amax has conducted studies on the economic feasibility of heating greenhouse complexes geothermally. These studies demonstrate that geothermal heating with some reasonable constraints is more economical and ecologically sound than alternative energy sources. The constraints mentioned include finding a hot water source at depths less than 1000 feet and utilizing the hot water near the well.

Geothermal space heating has a long and resounding history of success. Japan, Iceland, the United States and many other countries have used low ionic strength hot water for this purpose with great success. The Amax geothermal files contain case histories that are available for inspection.

Bill Long suggested that a demonstration geothermal greenhouse be erected in eastern Wyoming. The writer initiated a hydrogeochemical and geological reconnaissance of three hot springs in eastern Wyoming. They were Saratoga, Alcova and Douglas Hot Springs. This report proposes the development of Alcova Hot Spring for a low temperature geothermal heating system on the following grounds:

1. Water Chemistry:

   Low ionic strength waters are available in large volumes.

2. Temperature:

   The fluid temperatures are suitable for space heating.

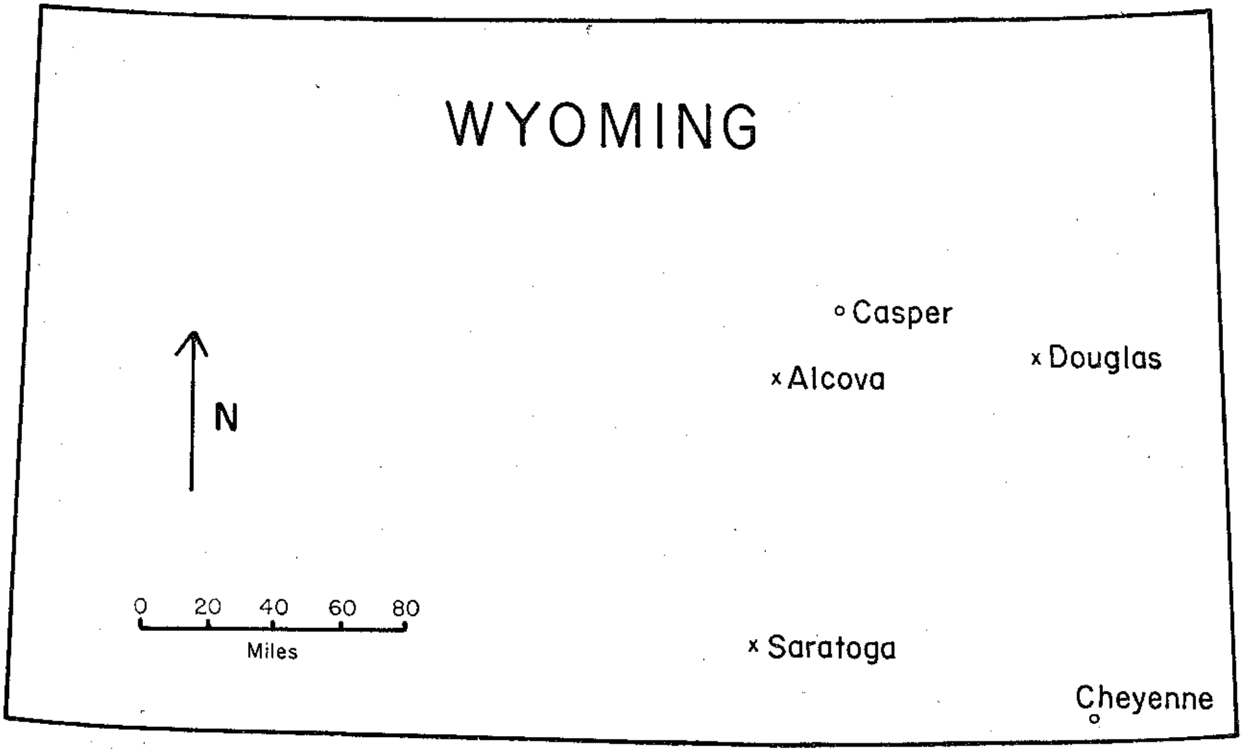
3. Depth:

   Hot water should be found at depths less than 1000 feet and perhaps at less than 500 feet.

4. Probable success:

   A shallow well in the vicinity of the Alcova power dam produces hot water and indeed has heated a large twin turbine generating house for about 25 years.

The geographic locations of Alcova, Saratoga and Douglas Hot Springs are shown below and on Figures 1, 2, and 3. Plates 1, 2, and 3 are pictorial descriptions of the same springs.



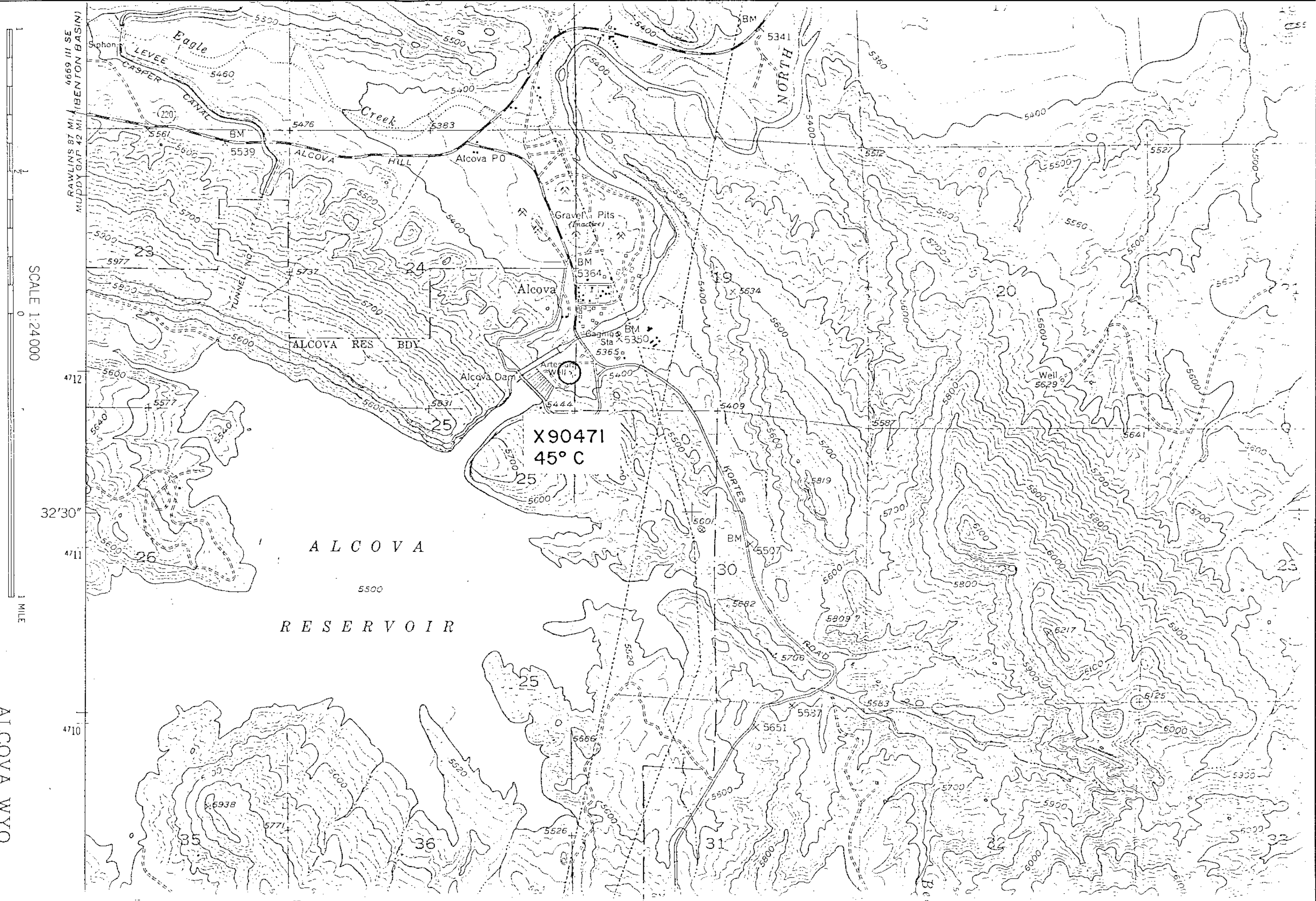


Figure 1. Location of Alcova Hot Spring, Alcova, Wyoming

ALCOVA, WYO.
N4230-W10637.5/7.5
1950

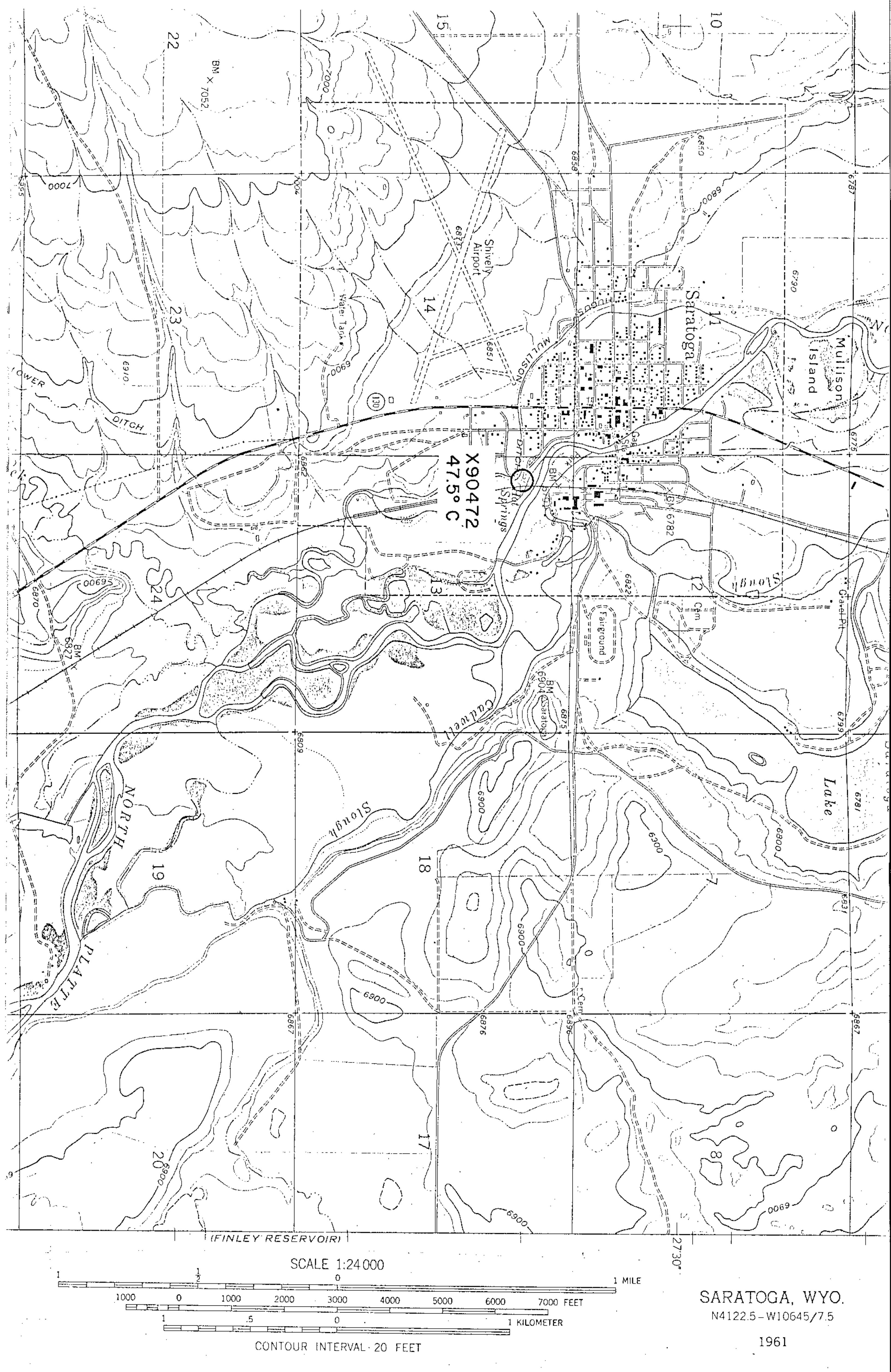


Figure 2. Location of Saratoga Hot Springs, Saratoga, Wyoming.

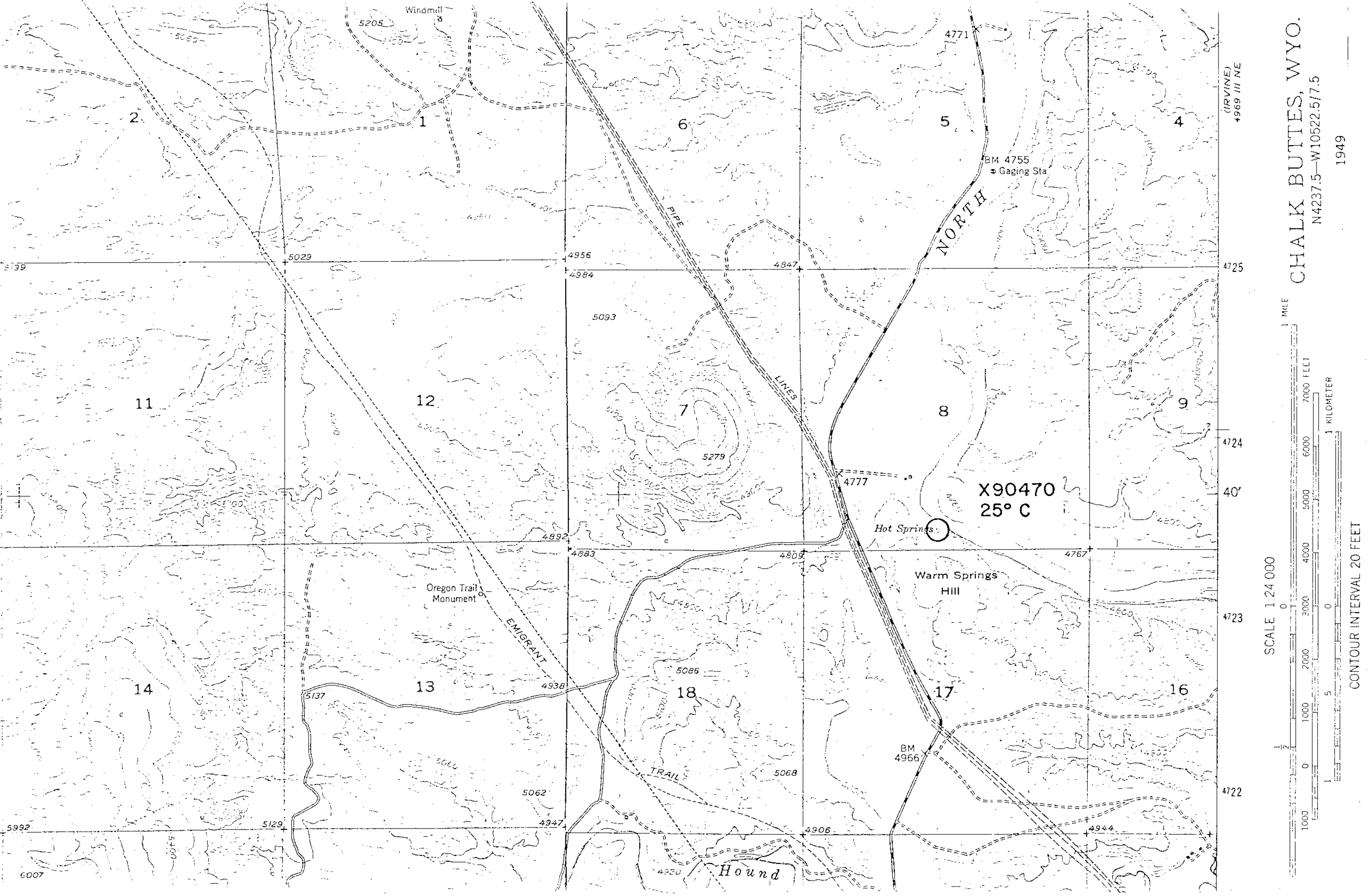


Figure 3. Location of Douglas Hot Spring, Douglas, Wyoming

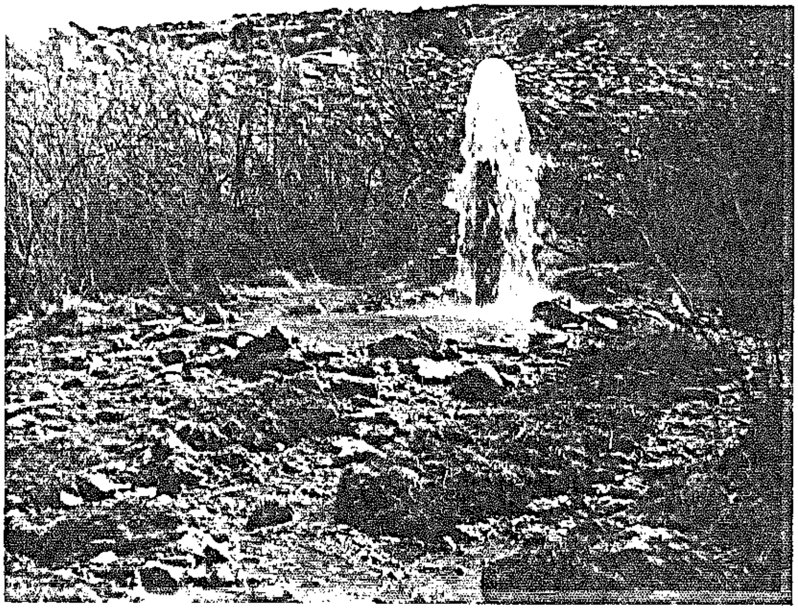


Plate 1. Alcova Hot Spring looking east.
T = 45°C

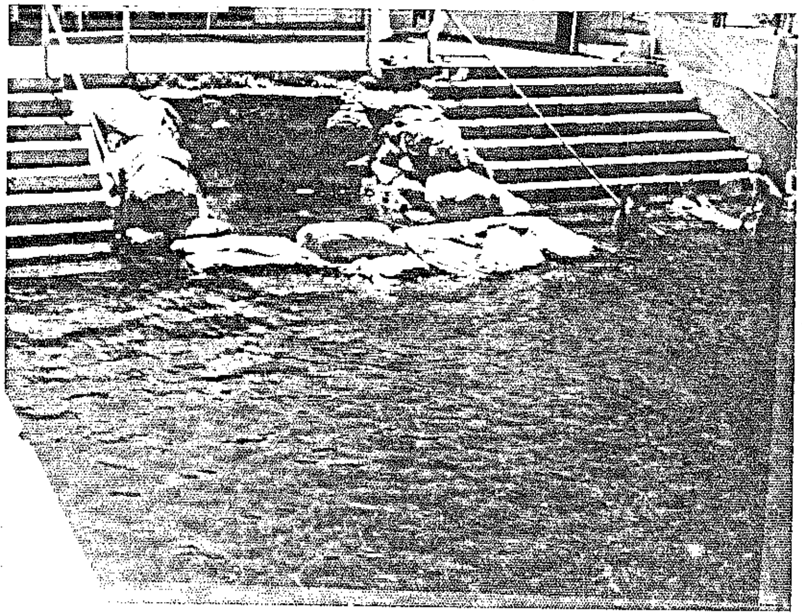


Plate 2. Saratoga Hot Spring looking south.
T = 47.5°C

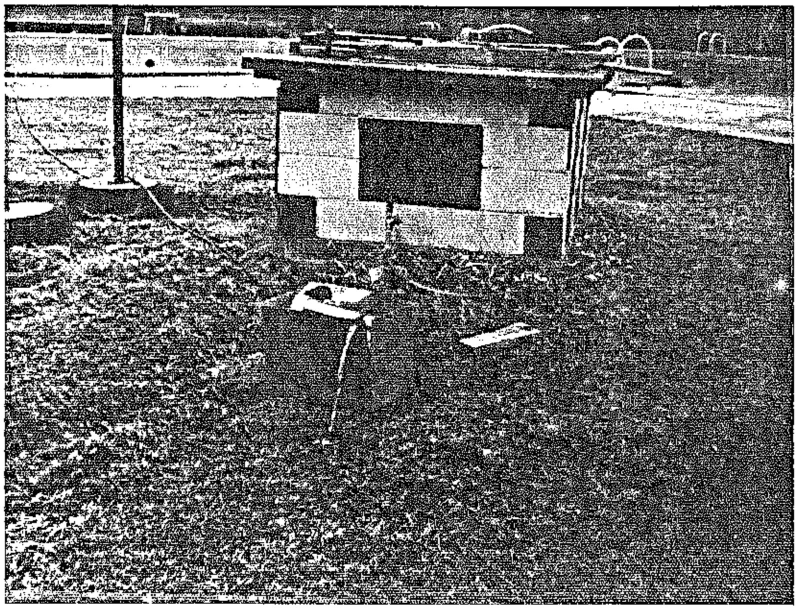


Plate 3. Douglas Hot Spring
T = 25°C

GEOLOGY OF THE ALCOVA AREA

The writer was limited to a two hour visit to the Alcova area and was able to determine that thermal water issues out of the Chugwater Formation as seen in Figure 4. The Chugwater Formation is a sequence of Triassic red shale and siltstone. Local sources have stated that thermal springs were present in the vicinity of the earth-filled dam and in the canyon now filled by the reservoir. This means that the impermeable dolomite and red shales of the Phosphoria Formation (see Figure 5) also transmit hot water. Therefore, local faulting may play an important role in transmitting thermal fluids.

The hot well drilled by the Bureau of Reclamation over 25 years ago is no deeper than 500 feet. The writer feels that probability favors finding hot water at similar depths. Nonetheless, a study of the local geologic cross section and faulting should be conducted before any well is drilled.

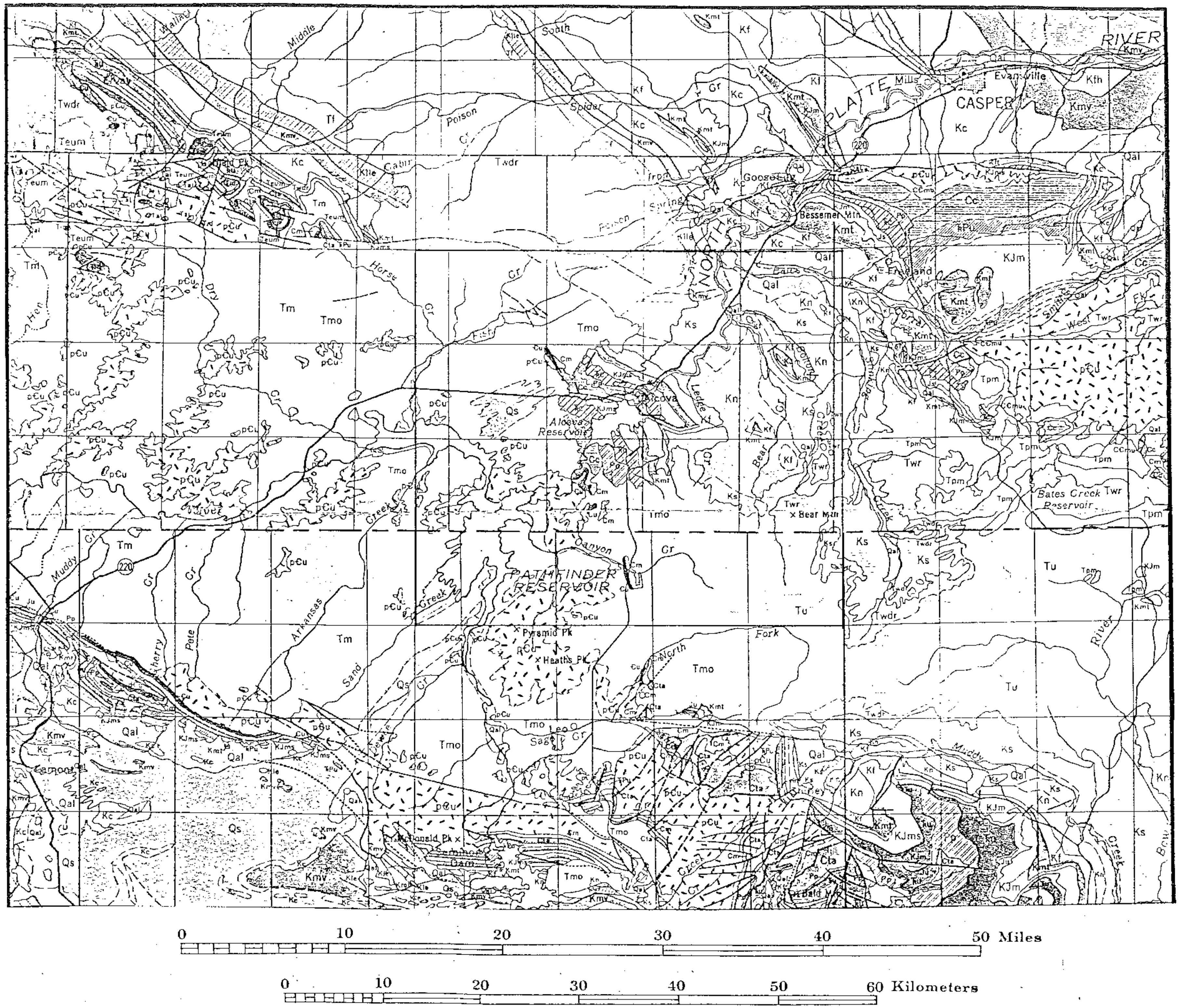


Figure 4. Geologic map of the Alcova, Wyoming area.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

GEOLOGIC MAP
OF
WYOMING

Compiled by J. D. Love, J. L. Weitz, and R. K. Hose

CRETACEOUS

Ks

Steele shale

Gray soft marine shale with numerous bentonite beds and thin lenticular sandstones

Kc

Cody shale

Gray soft marine shale with many lenticular sandstone beds and some bentonite beds

Kn

Niobrara formation

Light-colored limestone and gray to yellow, speckled limy shale

Kf

Frontier formation

Gray shale and sandstone; Wall Creek sandstone member at top

Kft

Frontier formation Mowry and Thermopolis shales

Kmt

Mowry and Thermopolis shales

Mowry shale is black and gray, weathers silvery gray, hard, contains thin bentonite beds and abundant fish scales; underlain by black soft Thermopolis shale with Muddy sandstone member 50 to 200 feet above base

Kcv

Cloverly formation

Light-gray to brown sandstone with black shale partings; chert pebble conglomerate in lower part

KJm

Cloverly and Morrison formations

Cloverly formation is light-gray sandstone and lenticular chert pebble conglomerate interbedded with variegated bentonitic claystone; the underlying Morrison formation consists of dully variegated siliceous claystone with nodular limestone and gray silty sandstone lenses

Jm

Morrison formation

Green siliceous claystone with limestone nodules and silty gray sandstone lenses

KJms

Cloverly Morrison and Sundance formations

Js

Sundance formation

Greenish-gray glauconitic sandstone and shale underlain by red and gray nonglauconitic sandstone and shale

JURASSIC

Ju

Jurassic rocks undivided

Includes Sundance formation and Nugget sandstone

TRu

Triassic rocks, undivided

Includes Jelm and Chugwater formations

TRIASSIC

TRc

Chugwater formation

Red shale and red siltstone with thin gypsum partings near base

TRPc

Triassic and post-Forelle Permian rocks

Includes Chugwater formation and gypsum, red shale, and dolomite beds equivalent to the Phosphoria formation of areas to the northwest

TRPu

Triassic and Permian rocks, undivided

Includes Chugwater formation and red siltstones and gypsum beds equivalent to the Dinwoody and Phosphoria formations of areas to the west

PERM

Pp

Phosphoria formation

Cherty gray and lavender dolomite interbedded with red shale and gypsum

Pu

Permian rocks undivided

Pfs

Forelle limestone and Satanka shale

Forelle limestone is gray, slabby, hard, crinkled; Satanka shale is red, soft, sandy

PENNSYLVANIAN

Cc

Casper formation

Gray and tan thick-bedded sandstone, underlain by interbedded sandstone and pink and gray limestone

Cta

Tensleep sandstone and Amsden formation

Gray sandstone and thin limestone and dolomite beds; basal part contains red and green shale; Darwin sandstone member at base

PCh

Hartville formation

In descending order: red and white sandstone, gray dolomite and limestone, red shale, and red and gray sandstone

MISSISSIPPIAN

Cu

Carboniferous rocks, undivided

Includes Tensleep sandstone, Amsden formation, and Madison limestone

Cm

Madison limestone

Blue-gray massive cavernous cherty limestone and dolomite; arkosic sandstone present in places at base may be of Cambrian age

Cg

Guernsey limestone

Blue-gray massive cherty limestone and dolomite. Locally includes dolomite and sandstone of Devonian age

DEVONIAN

CCmu

Madison limestone and Cambrian rocks, undivided

SILURIAN

ORDOVICIAN

CAMBRIAN

Cambrian rocks, undivided

Chiefly thin-bedded glauconitic sandstone and quartzite

CHEMISTRY

The waters of all three springs seen in Table 1 have near neutral pH. Low temperature hot water systems are indicated by high levels of Cl, F, Ca and Mg. Hot water systems are also indicated by values that are greater than unity for the Cl/SO_4 and Cl/F ratios. The waters of the three springs may be described as follows:

Spring name	Water type		Inferred age
Alcova H. S.	$SO_4>Cl>HCO_3$	Na>Ca>Mg>K	Middle
Saratoga H. S.	$SO_4>Cl>HCO_3$	Na>Ca>K>Mg	Oldest
Douglas H. S.	$SO_4>HCO_3>Cl$	Ca>Na>Mg>K	Youngest

Alcova and Saratoga Hot Springs are not remarkably different even though Saratoga Hot Spring contains almost twice as many dissolved solids.

Quartz and Na-K-Ca subsurface temperatures seem realistic and indicate that thermal water has probably not been diluted with cold meteoric water. Subsurface temperatures probably do not exceed 100°C and in the case of Alcova and Douglas Hot Springs maximum temperatures are only slightly higher than the spring temperatures.

Table 1. Chemical analysis of three thermal springs in eastern Wyoming. Units are mg/l unless otherwise noted.

	Alcova Hot Spring X90471	Saratoga Hot Spring X90472	Douglas Hot Spring X90470
pH (field)	7.50	7.51	7.42
Cl	230	540	60
F	2.3	6.0	1.1
HCO_3	87	62	159
CO_3	0	0	0
SO_4	340	580	220
SiO_2	34	72	30
Na	170	480	78
K	9.5	22	7.6
Ca	160	150	100
Mg	22	11	25
Li	0.2	1.1	0.1
B	<1.0	<1.0	<1.0
NH_3	0.04	0.01	0.01
H_2S	<0.05	0.90	<0.05
TDS	1061	1931	686
T°C	45	47.5	25
Flow (gpm)	300	50	5
$TSiO_2$ °C	85	120	79
TNa/K °C	124*	108	181*
TNa-K-Ca °C	59	99	54
Cl/SO_4	1.8	2.5	0.7
Cl/F	53.6	48.2	29.2
CL/HCO_3	4.5	1.5	0.6
Cations mg/l	17.5	29.9	10.6
Anions mg/l	15.1	28.6	8.9

* Does not reflect true subsurface equilibrium conditions.

Solution mineral equilibria studies of Alcova Hot Spring indicate that waters were last in equilibrium with the minerals listed in Table 2. This silica-carbonate mineral suite fits the geologic environment in that the springs issue out of the Chugwater Formation of Triassic red shale and siltstone with some calcite cement.

Equilibria studies also indicate by virtue of the very small ΔG values seen in Table 2 that the waters are only slightly saturated with the minerals listed. Therefore, pipe scaling and other problems associated with mineral precipitation should be minimal. This is born out by the dearth of problems in the space heating system at the Alcova power house in over 25 years of utilizing thermal water.

Table 2. Gibbs Free Energies of various hypothetical minerals in Kcal/mole. Positive values indicate saturation, 0 indicates equilibrium and negative values indicate undersaturation.

Alcova Hot Spring
X90471

Mineral Name	Chemical Formula	ΔG
Aragonite	$CaCO_3$	0.19
Calcite	$CaCO_3$	0.26
Chalcedony	SiO_2	0.13
Dolomite	$(Ca, Mg)(CO_3)_2$	0.08
Quartz	SiO_2	0.66
Talc	$Mg_3(Si_4O_{10})(OH)_2$	6.39
Tremolite	$Ca_2Mg_5(Si_8O_{22})(OH)_2$	6.52

CONCLUSION

The Alcova, Wyoming area exhibits high potential for low temperature geothermal development. The following meritorious points are noted:

1. Waters have low ionic strength and are not saturated to any degree with ions.
2. Temperatures of 45 to 60°C should be achieved at depths less than 1000 feet and probably less than 500 feet.
3. The quantity of hot water should be near unlimited.
4. The area is on Highway 220 only 30 miles from Casper, Wyoming.
5. Federal land may be available in the area of interest.

The following work should be undertaken:

1. Determine local faulting and the geologic cross sections in several days of geologic mapping.
2. Determine the land status in the vicinity of the power dam.
3. Acquire meteorological records for the Alcova-Casper area to determine the number of blue sky days and average winter conditions.

The following positions should be taken assuming that the preceding work returns favorable results:

1. Acquire a suitable land position depending on the size of the greenhouse complex.
2. Drill a well.
3. Design the space heating system to accomodate fluid temperatures found and greenhouse geometry.
4. Build the complex or entice a second party to build the structure utilizing Amax hot water.