MEMORANDUM

August 30, 1979

TO: Mike Wright

FROM: Debbie

SUBJECT: Utah Roses Report by Energy Services, Inc.

This report was prepared for Utah Roses by Jay Kunze et al.

The report is poorly written and reaches some conclusions about the geothermal potential of the Utah Roses property based on some very tenuous geologic arguments.

P. Murphy, P. M. Wright and D. Struhsacker are acknowledged in the report as "... most helpful in reviewing the assessment of the resource and in the gathering of the data."

From this acknowledgement, one could infer that UGMS and ESL helped compile some of the specious data, and agree with their interpretation.

Some of the more misleading statements included:

> "If the fault zone does indeed exist...(inferred from an aeromag anomaly)...and carries geothermal water, horizontal movement of the water into the valley fill material can be expected. Since Utah Roses is less than ½ mile away from the projected fault trace, it can be considered a good geothermal exploration area." pg. 10

> "The possibility that a fault zone may exist within 2,600 feet of the Utah Roses property and the downhole temperatures encountered in the Conservancy Well (93°F) and Sandy City well (100°F).. (n.b.- this well is over 2 miles away and has a bottom hole temperature of 90°F)....make the Utah Roses property an excellent geothermal prospect pg.24.

P. Murphy has sent an unfavorable review of the report to Keith Jones of Eg&G.

Should we respond in kind?

Debbie

Debbie Struhsacker

DS/hb

Enclosure - Utah Roses Report

STRUHSACKER

GEOTHERMAL EVALUATION
OF THE
SANDY, UTAH AREA

submitted to:

UTAH ROSES, INC.
567 W. 90th S. (Sandy)
SALT LAKE CITY, UT 84070

Prepared by

ENERGY SERVICES, INC.
1084 N. SKYLINE DR.
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July, 1979

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ACKNOWLEDGEMENTS

The Utah Geological and Mineral Survey (Peter J. Murphy and Ben L. Everitt) and the University of Utah Research Institute (Phillip M. Wright and Debra W. Struhsacker) were most helpful in reviewing the assessment of the resource and in the gathering of the data. The Salt Lake County Water Conservancy District cooperated in sharing costs of testing the conservancy well. Consultant Jack Barnett was most helpful in providing perspecti\ in terms of the water rights and geological/hydrological assess

GEOTHERMAL EVALUATION
OF THE
SANDY, UTAH AREA

A. INTRODUCTION

This study was conducted under contract to Utah Roses, Inc. in support of a Department of Energy (DOE) Program Opportunity Notice (PON) project. The PON is a cooperative project between Utah Roses, Inc. and DOE designed to demonstrate the useful space heating application of geothermal energy to the floral industry.

The primary objective of the study is to evaluate and select the most geologically favorable sites for the drilling of geothermal wells around Sandy, Utah, specifically the Utah Roses, Inc. property. All readily available data (reports, maps, surveys, and studies) were examined and the pertinent data evaluated in regard to the occurrence of the geothermal resource. This study presents the interpretation of the pertinent data, reconnaissance findings, and recommendations concerning geothermal drilling sites.

B. LOCATION

Utah Roses, Inc. is located in the southern part of the Jo Valley which is situated in north-central Utah. The greenhous complex is located approximately 13 miles south of Salt Lake (90th south, just west of I-15 in Sandy, Utah. See Figure 1.

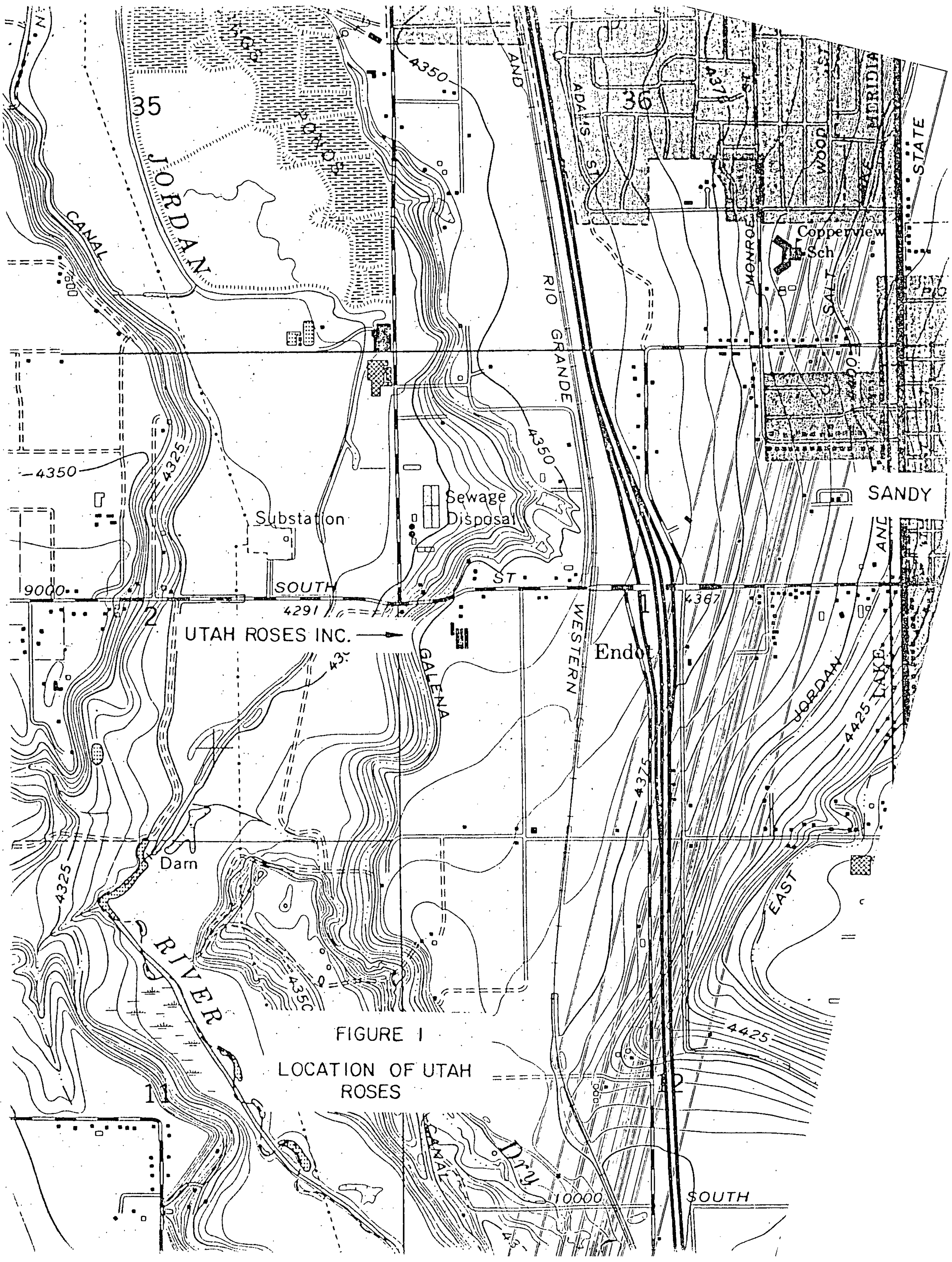


FIGURE 1

LOCATION OF UTAH ROSES

C. GENERAL TOPOGRAPHY AND HYDROLOGY

The Utah Roses, Inc. property is located in the Jordan Valley, a structural valley on the eastern edge of the Basin and Range physiographic province. The valley has an area of about 400 square miles with Salt Lake City located in the northeast portion. The town of Sandy is near the southern end of the valley, located about 6 miles west of the mouth of Big and Little Cottonwood Canyons.

The valley is bounded on the east by the Wasatch Range, with peaks higher than 11,000 feet above mean sea level and a local relief of about 6,000 ft. On the south the valley is bounded by the Traverse Mountains, whose relief is about 2,000 ft. On the west are the Oquirrh Mountains with a relief of 4,000 ft. The valley floor is relatively flat and slopes gently northward.

The principal source of surface water is the north-flowing Jordan River and six major creeks that drain the Wasatch Range. Most of these creeks drain from about ten miles back of the mountain front and flow westward through deep canyons. When the streams exit from the mountains, they flow westward across deposits of coarse unconsolidated material at the edges of the valley, losing part of their flow by influent seepage. This water recharges the vast ground-water basin that consists of unconsolidated deposits of gravel, sand, silt and clay. No perennial streams enter the valley from the Traverse or Oquirrh Mountains.

D. GENERAL GROUND WATER

The ground water in the Jordan Valley occurs in three general divisions: a shallow unconfined ground-water body, local perched water, and an artesian reservoir. Ground water is unconfined along the benches and forms a continuous body with the artesian reservoir in the central valley. Most of the recharge to the ground-water system is along the benches. The bulk of the ground-water resource is in the artesian reservoir in the lower portions of the valley.

The sediments that filled the Jordan Valley were deposited by several forces in several environments, and the complex pattern of deposition resulted in a ground-water aquifer that ranges widely from place to place in permeability and porosity. The lensey and discontinuous aquifers have been divided into six districts based on geology, water-bearing properties of the deposits, and the quality of the ground water.

The Sandy area can be described at depth, geohydrologically, as large thicknesses of well-sorted gravels interbedded with lake-bottom clays. There are also numerous channel gravels of ancient perennial streams. The ground-water moves generally northwest, responding irregularily to climatic changes. There exist many large diameter wells with hand dug wells common. Most wells are less than 150 feet in depth and under flowing artesian conditions. Specific capacities range from 6-200 gpm/ft with an average of 45 gpm/ft.

E. GENERAL GEOLOGY

The Jordan Valley lies at the eastern edge of the Basin and Range physiographic province, bounded on the east by the Wasatch Range and on the south and west by the Traverse and Oquirrh Mountains. The valley is a graben and the surrounding mountains have been uplifted relative to the valley. The boundaries between the valley and mountains are most often marked by faults. In addition to the boundary faults separating the Jordan Valley from the adjacent mountains, other faults, more or less in the middle of the valley, define an inner graben which contains a considerable thickness of sediment derived from the adjacent mountains.

The Wasatch fault zone separates the Wasatch Range from the valley and is the predominate feature in the area. The fault zone is a typical Basin and Range normal fault zone. It consists of a sevier of individual faults with a braided or branching pattern. Most of the faults in the valley and on the east side strike N-S and dip 55° to 75° to the west. Those on the west side of the valley strike N-S and dip to the east at approximately 60°.

The Wasatch Fault zone and associated faults are currently active and movement along them have resulted in 58 strong earthquakes from 1850 to 1949. Generally, however, the majority of the disturbances have been relatively minor in nature and undetectable to the general populace. It would appear that the movements began in late Tertiary and have continued intermittently to the present time. The latest movement on the Wasatch Fault is that of normal upthrusting with the mountain block being uplifted carrying sediments of the Lake Bonneville group and younger alluvial fans upward from 60 to 200 feet.

The total vertical displacement along the Wasatch Fault zone is difficult to estimate because of the amount of sedimentation that has accumulated in the valleys and the covering of many of the fault lines. Several faults have been inferred from gravity surveys, but their displacement can only be estimated. There are few deep wells in the area and generally wells do not exceed 800 ft. in depth. However, the vertical displacement would appear to be at least 750 ft. and probably 3,000 ft. or more.

The mountains that surround the area are composed of rocks that range in age from Precambrian to Recent. In the Wasatch Range to the east of the valley, the rocks include thick sequences of sedimentary rocks of Precambrian, Paleozoic, Mesozoic, and Cenozoic age intruded by granitic rocks of Late Cretaceous or early Tertiary age. The Traverse Mountains to the south consist principally of rocks of the Oquirrh Formation of Pennsylvanian and Permian age and of sedimentary and volcanic rocks of Tertiary age. The part of the Oquirrh Mountains that borders the Jordan Valley to the west is composed of Paleozoic rocks, principally of the Oquirrh Formation, but including Mississippian rocks, and sedimentary, intrusive, and extrusive rocks of Tertiary age.

Among the most impressive aspects of the landscape of the area are the deposits and erosional features of Lake Bonneville. Tremendous embankment deposits of gravel and sand are at the mouths of many canyons and at the Jordan Narrows. Sharp shorelines of Lake Bonneville are etched in bedrock and in pre-Lake Bonneville alluvial fans alike all around the valley. The most prominent shore lines are the Bonneville, ranging from about 5,135-5,180 feet, and the Provo at about 4,800 feet elevation.

The Wasatch Mountains are also characterized by folded sedimentary strata (intense folding locally) and intruded granite. Several steep-sided E-W canyons open out onto the Valley proper. These canyons are the direct result of glaciation, faulting or differential erosion depending on the individual canyon.

Alluvial deposits were laid down in the valley both before and after Lake Bonneville. On the west side of the valley the Tertiary deposits that have been pedimented by later erosion are principally stream or mudflow deposits. All over the valley minor stream activity since Lake Bonneville time has scarred or obscured older deposits.

The earth movements that originally formed the valley have continued into comparatively recent times and have formed scarps in the unconsolidated deposits of the valley. The most prominent of the faults showing late movement is the East Bench fault which is marked by a scarp that reaches a height of 80 feet in the unconsolidated deposits in the northeastern part of the Jordan Valley. The west-facing scarp of the East Bench fault, together with the east-facing scarps of the Jordan Valley fault zone delineate an inner graben within the Jordan Valley.

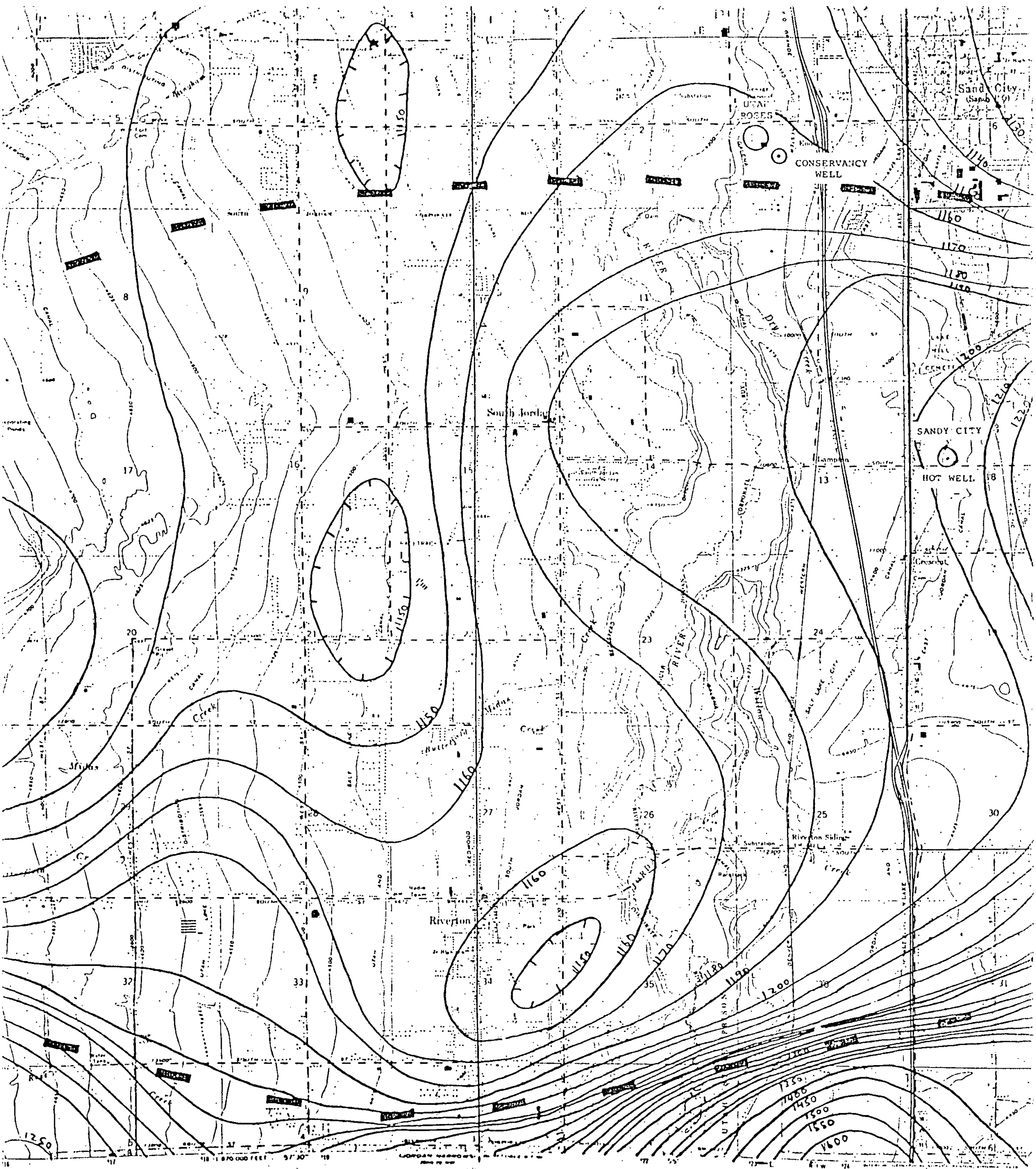
The late surface geology of the Jordan Valley consists principally of unconsolidated deposits laid down by the streams, lakes, and winds in Quaternary time. There are also extensive outcrops of pre-Quaternary rocks generally in areas where pediments formed at the base of the mountains. The history and sequence of deposition is complex and no stratigraphic sequence is applicable to the valley as a whole. The principal rock types in the valley fill are made up of interbedded clay, silt, sand, gravel, tuff, and lava. The thickness of the fill material is in the order of 3,000 feet in the vicinity of the Utah Roses property. The fill may be as much as 5,000 feet deep in the area approximately four miles west. The estimated thickness of the fill is based on well depth, aeromagnetic data, and gravity data compiled by the USGS.

F. GEOTHERMAL DATA EVALUATION

1. Aeromagnetic Map

An aeromagnetic survey was run in the southern Jordan Valley by Books of the USGS in 1954. The data was plotted and a map prepared by ASARCO in July, 1954. The map shows the magnetic gradient of the valley floor. Steep magnetic gradients on the north side of the Traverse Mountains in the south and the presence of Crystal Hot Springs in the same area would indicate the presence of an east-west trending fault zone. The map also shows a relatively steep magnetic gradient trending E-W that passes just south of Sandy and the Utah Roses property. See Figure 2.

The Sandy magnetic gradient has been recorded as an E-W trending fault zone on several maps of the area. The source of this interpretation has been impossible to track down and verify. Some workers, in fact, see no definite indication of faulting based on the available geophysical data. However, the fact the valley fill material is in excess of 3,000 feet deep in the area immediately west of Sandy, may account for the magnetic gradient becoming less definative in the area around Utah Roses. The steep gradient that shows up south and east of Sandy would indicate the definite possibility of a fault zone in that area. If the fault zone does indeed exist and carries geothermal water, horizontal movement of the water into the valley fill material can be expected. Since Utah Roses is less than 1/2 mile away from the projected fault trace, it can be considered a good geothermal exploration area.



ublished by the Geological Survey

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1962. Field checked 1963

927 North American datum
in Utah coordinate system, central zone
ansverse Mercator grid ticks

in which only landmark buildings are shown

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ion of urban areas

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ROAD CLASSIFICATION

Heavy duty — Light duty
Medium duty — Unimproved dirt
U.S. Route — State Route
Interstate Route

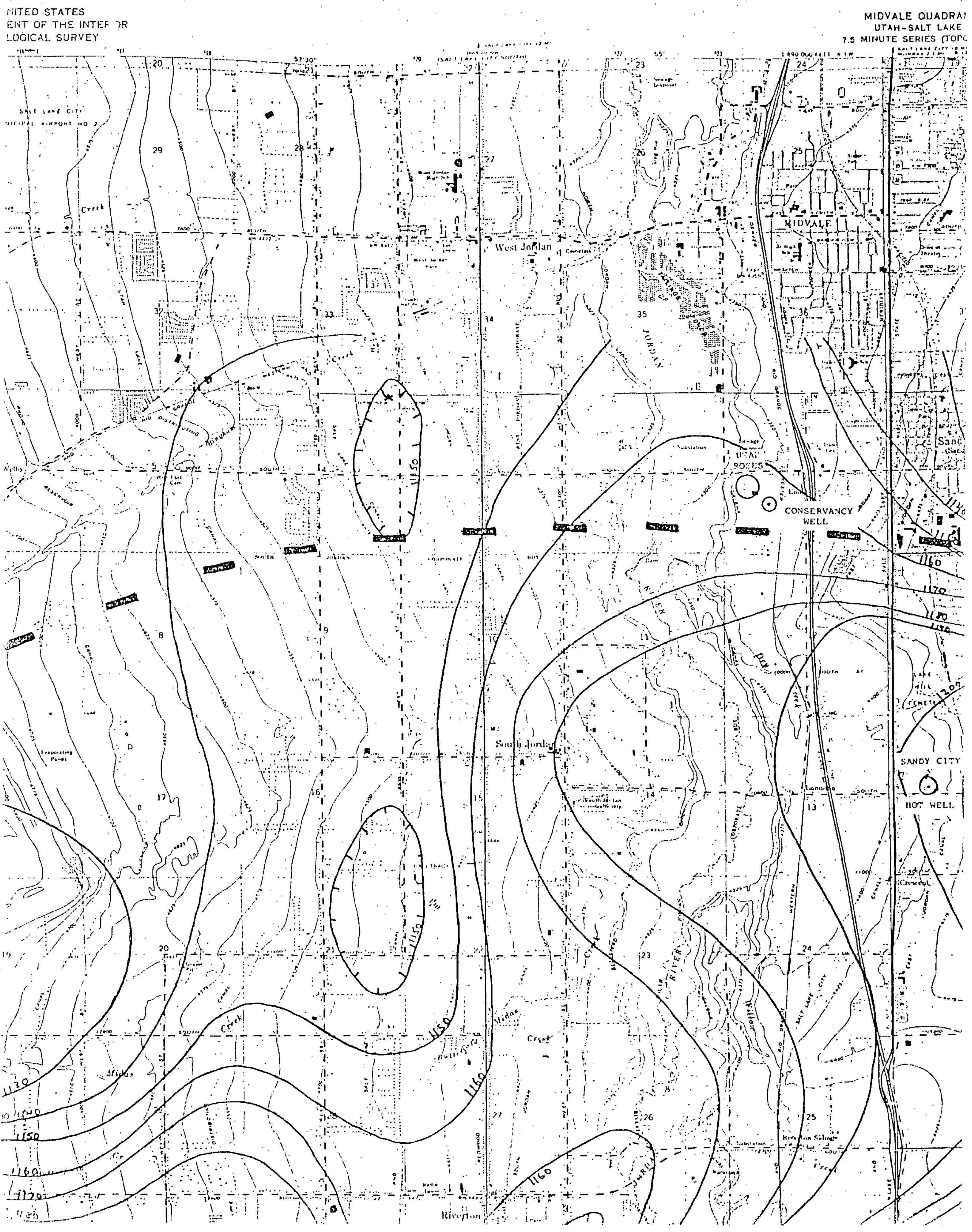
FIGURE 2

USGS TOTAL INTENSITY
AEROMAGNETIC MAP
DRAPER PROJECT

CONTOUR INTERVAL
10 and 50 GAMMAS

MIDVALE, UTA
N4030—W11152.5/

1963
PHOTOREVISED 1969 AND
AMS 3665 III SW—SERIES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SANDY CITY
HOT WELL
Riverton
Evaporating Ponds
1150
1160
1170
1180
1190
1200
1140
1130
1120

2. Valley Thermal Springs

There are numerous hot springs that occur within the State of Utah. Reported temperatures of these springs range from 68°F to 189°F. Nearly all of them are near or in known fault zones. See Figure 3.

Two of these springs are in the general vicinity of the project site. Crystal Hot Springs is located approximately 6 miles south of the site at the Utah State Prison. The water temperature is reported at 137°F with a minimum projected temperature of 225°F at depth; based on the silica concentration (55 ppm). Saratoga Hot Springs is 16 miles south of the project site on the west bank of Utah Lake. It flows with a reported temperature of 111°F with a minimum projected temperature of 160°F at depth; again based on the silica concentration (25 ppm).

Both of these springs are located along separate fault zones and are undoubtedly a mixture of the geothermal resource and cold ground water. When cold water mixing is assumed, the possible reservoir temperature of Crystal Hot Springs water is 350°F and 250°F for Saratoga Hot Springs. The total dissolved solids of both springs are about 1500 ppm and the waters are of the calcium sodium chloride type. However, Saratoga Hot Springs is higher in sulfate (420 ppm) than Crystal Hot Springs (140 ppm). Otherwise the waters are very similar and indicate that the source water may be of similar origin.

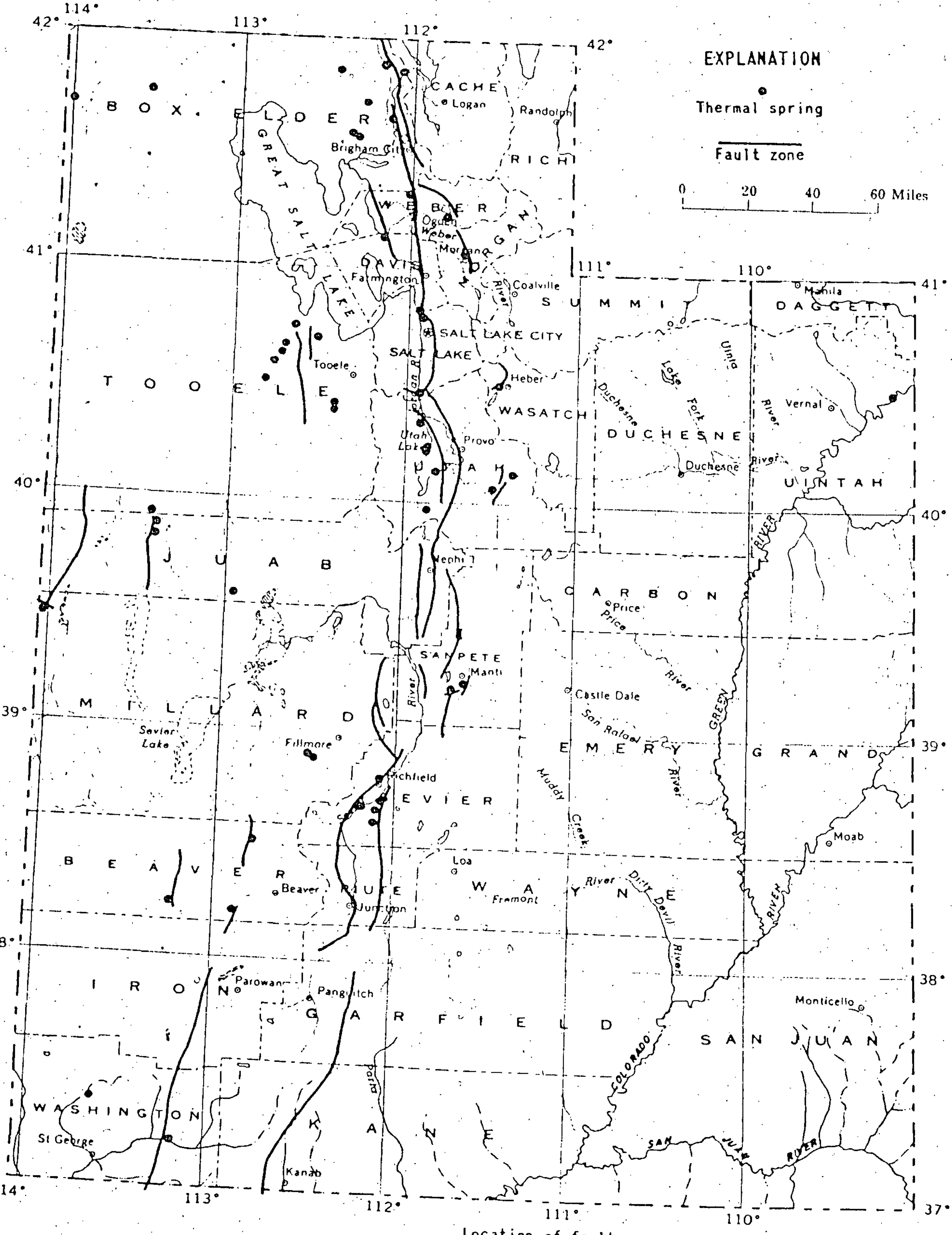


FIG. 3

THERMAL SPRINGS AND MAJOR FAULT ZONES OF UTAH

(Taken from Utah Geological and Mineralogical Survey Water Resources Bulletin 13, 1970)

The springs occur along the fault zones where the quartzite bedrock has been uplifted against the valley fill material. The presence of these springs indicate that the major faults in the area provide the channels and permeability for movement of the geothermal waters. It is reasonable to assume that the geothermal waters also move horizontally away from the fault zones into the valley fill material.

3. U.S.G.S. Circulars 726 and 790

Crystal Hot Springs (6 miles south of Utah Roses) is listed as a possible 275°F subsurface reservoir based on geochemistry in Circular 726. The spring discharge is listed at 136°F, with a dissolved solids content of 1430 ppm. Crystal Hot Springs consists of four springs discharging approximately 60 gpm total from unconsolidated valley fill. Circular 726 does not cover Saratoga Hot Springs at all.

Circular 790 reports both hot springs as part of the Wasatch Front group with discharge temperatures between 95°F and 136°F. It states that all the springs result from deep circulation in fault zones and have high yields of moderately saline to briny water.

4. Utah State Forestry Well No. 1

This well was drilled on the Utah State Prison grounds right next to Crystal Hot Springs. Total depth of the well is 280 feet. Fractured quartzite bedrock was encountered at 265 feet in a fault zone. No water production occurred below the fault zone. An artesian flow rate of 12 gpm was recorded with a discharge temperature of 167°F. A maximum downhole temperature of 175°F was recorded on April 27, 1978. The well was cased from a depth of 170 to 280 feet. Originally the water surface was 2 feet below ground level and only developed flow (12 gpm) after it was cleaned out by jetting compressed air down the hole.

This well indicates the importance of fault zones as geothermal water sources and zones of permeability. It verifies that 167°F geothermal water is present in the area at shallow depths and can be recovered easily. The horizontal extent of the reservoir can not be determined from the present well data. However, it appears that the geothermal water is moving upward and laterally within the fault zone with leakage occurring horizontally into the permeable sands and gravels of the valley fill material. Apparently there is no significant production coming from the quartzite bedrock unless it is fractured.

5. Salt Lake County Conservancy Well

This well was completed in January, 1966 to a total depth of 800 feet. The well is located approximately 1,000 feet southeast of the center of the Utah Roses property. See Figure 2. The well had a reported discharge temperature of 76^{0} during a 27 hour pump test (728 gpm) in 1966. The well has been static and not used since it was drilled.

The well was temperature logged and pump tested in June, 1979. Figure 4 shows the temperature log made on June 4th before anything was done to upset the well or the water within the wellbore. On June 6th the well was pumped for approximately 6 hours at a nominal 1,000 gpm. The well drawdown was only a total of 90 feet (55 to 145) during the pump test. The water level would have probably stabilized at approximately 165 feet (110 feet of drawdown) after the six hours of pumping if the pump had not gone off for 10 minutes about 4½ hours into the test.

FIG. 4

SALT LAKE COUN
CONSERVANCY WEL
LOG
JUNE 4, 1979

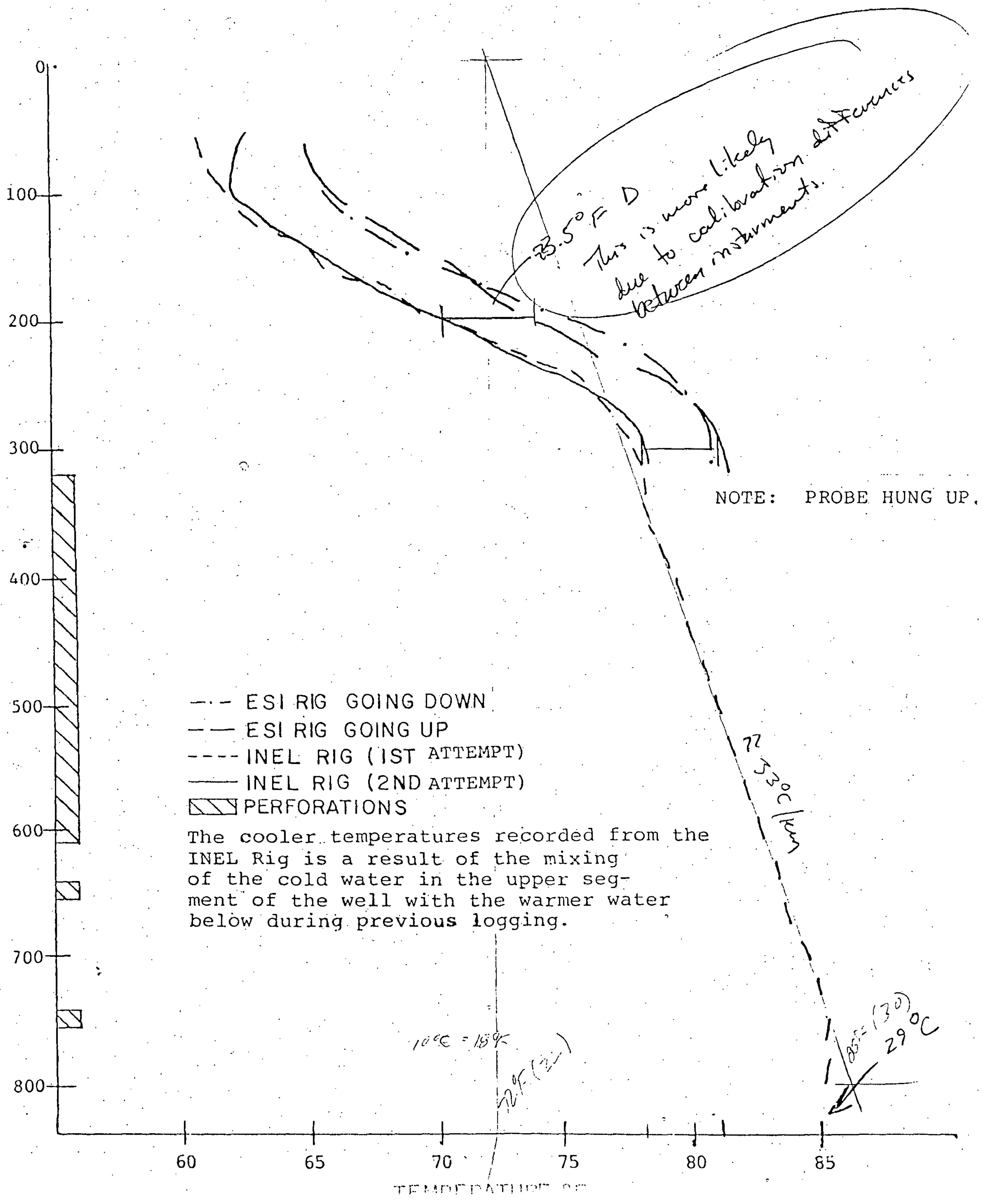


TABLE 1

Salt Lake County Conservancy

Well Water Chemistry

(results in ppm unless otherwise indicated)

$CaCO_3$ (Alkalinity)	112	As	.005
Ba	.11	HCO_3	137
B	.160	Cd	<.001
Ca	16	CO_3	<.01
Cl	20	Cr (Dis)	<.001
Cr (Hex.)	<.001	Conductivity (μmhos/cm)	330 @25c?
Cu	.001	F	.56
$CaCO_3$ (Hardness)	42.0	Fe (Dissolved)	.150
Fe (Total)	.590	Pb	<.001
Mg	2.88	Mn	.030
Hg	<.0002	Ni	<.001
NO_3-N	<.01	K	1.76
Se	<.001	SiO_2	13
Ag	<.001	Na	58
SO_4	26.0	TDS	212
S	<.01	Turbidity NTU	460
pH Units	7.48	Zn	.002

Several geochemical samples were taken during the pump test and analyzed. Those results are shown in Table 1. After examining the data and performing geochemical analysis, there was a suspicion that the bottom of the well was producing hotter water than was recorded during the initial temperature log of June 4th.

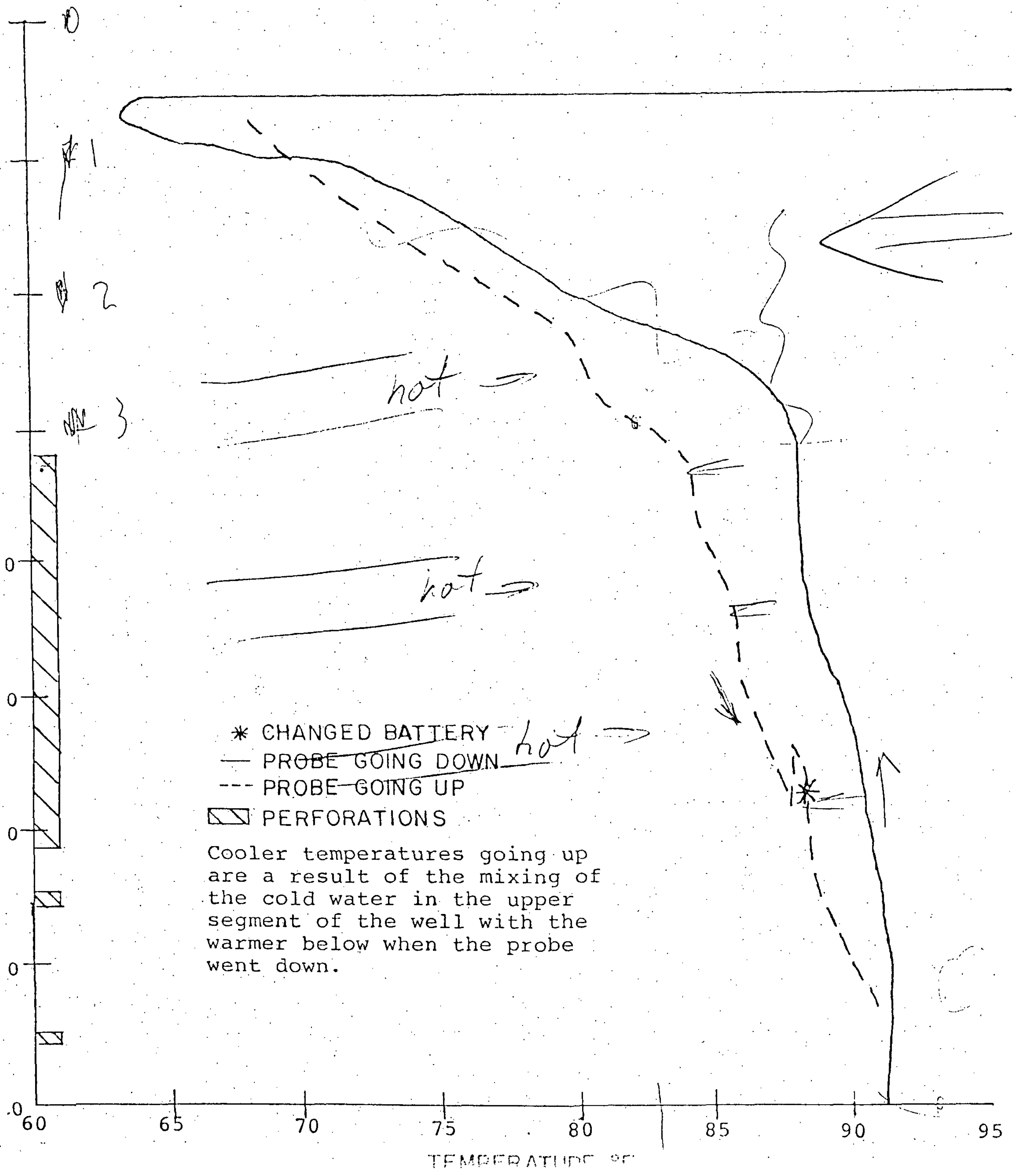
Consequently, the well was temperature logged again on June 25th. Those results are shown in Figure 5. The bottom hole temperature was 93^{0}F. Apparently, the strenuous pumping of the well brought in warmer geothermal water and this water was not completely cooled to the normal equilibrium conditions before the second log was made, 2½ weeks after the pumping of the well. If the well were designed as a geothermal well (case out the cold water above 520 feet), it is capable of producing water at approximately 90^{0} F.

A temperature gradient of 3.1^{0}F/100 ft is derived when using the 77.5^{0}F at 300 feet and 93^{0} at 800 feet. A temperature gradient of 1.7^{0}F/100 ft results when using the data from the June 4th temperature log. Using an average (2.5^{0}F/100 ft) temperature gradient the following is the estimated temperature at the given depth.

	Temperature	
Depth	Estimated	Range
800 feet	90^{0}F	
2,000 feet	120^{0}F	(110 - 127^{0}F)
3,000 feet	145^{0}F	(127 - 158^{0}F)
4,000 feet	170^{0}F	(144 - 189^{0}F)

SALT LAKE COUNTY
CONSERVANCY WELL LOG
JUNE 25, 1979

FIG. 5



For the purposes of geochemical analysis, it was conservatively assumed that the 93^0F water was being mixed with 62^0F cooler water nearer the surface, to give the well head flowing temperature of 78^0F. It is more likely however, that the cooler near surface water is in the range of 50-55^0F.

very hard to believe

The net conservative result is nominally a 50/50 dilution, giving the following geochemical temperature indications:

Silica	158^0F
Na/K/Ca	135^0F

These results are in good agreement and support the previously selected production target zone below 2,000 feet. This well is the single most definitive evidence for a viable geothermal resource in the area. It indicates that the minimum temperature required (120^0F) is present and can be recovered at a reasonable depth. The production rate (1,000 gpm) and drawdown (110 feet after 6 days) indicates that the geothermal well can be expected to produce a reasonable flow rate over a 6 month period. The valley fill material apparently extends down to approximately 3,500 feet in the vicinity of Utah Roses and the permeability should not result in production rates less than half of those in the Conservancy Well. If faulted and/or fracture zones are encountered, the estimated production rates and temperatures could be greatly increased.

Assumes permeability will not change with depth, or that permeability is predictable in the target zone. These are not good assumptions

6. Other Area Warm Wells

There are numerous other warm wells that occur around the Utah Roses area. These wells have not been discussed in detail due to the limited information concerning them and the fact that the Conservancy Well data is much more definitive and site specific. The fact the other wells exist indicates that geothermal waters are leaking away from the primary fault sources and can be located in selected permeable aquifers at depth.

However, there is data available from the driller's log of one other well that is important and should be noted. This well is located at approximately 150 East 10600 South (11,000 feet southeast of Utah Roses) and was drilled by Sandy City. See Figure 2. The well was drilled in late 1958 and early 1959 to a total depth of 1150 feet. It was pump tested at 1,000 gpm and the drawdown was 79 feet over an unknown time period. The static water level was 71 feet and the drawdown dropped the level to 150 feet.

During the 1,000 gpm pump test, the well flowed water at 90^{0}F. The well was then plugged with rock and 300 lbs of lead wool between 722 and 740 feet. The reported temperature of the water produced above 722 feet was still 82^{0}F. Another plug was placed between 385 and 415 feet (rock and 3,000 lbs of lead wool. The produced water temperature above this plug (385 feet) was still a reported 72^{0}F. The well was then plugged with rock and cement from 315 to 355 feet and left undeveloped.

Again, this well demonstrates that > 100^0F geothermal waters are present in the area at depth. It is estimated that the maximum downhole temperature of this well would be in the 100 - 110^0F range. The well casing was essentially perforated from 252 feet to total depth and the colder waters from above 385 feet were continually mixing with the geothermal water originating deeper.

G. GEOTHERMAL RESOURCE POTENTIAL SUMMARY

1. Geothermal Hydrology

It appears that the geothermal waters are present within the major area fault zones and move laterally and upward in them to points of reduced pressure. There is apparent lateral leakage of the waters away from the fault sources into some permeable beds. The hottest and most productive wells (for a given depth) can be expected when they are drilled into the faulted and fractured zones. However, it appears that good production and temperatures can also be located away from the fault zones if permeable beds are encountered and/or the wells are drilled to the quartzite bedrock. The possibility that a fault zone may exist within 2,600 feet of the Utah Roses property and the downhole temperatures encountered in the Conservancy Well (93^0F) and Sandy City well (> 100^0F) to make the Utah Roses property an excellent geothermal prospect. The success of this project will have a great impact on the Jordan Valley in terms of alternate energy resources.

2. Production Well

The production well will be located close to the possible E-W trending fault passing through Sandy. The Utah Roses, Inc. greenhouse complex is in an ideal location and a convenient site has been selected on their property. The production of the well will be dependent upon the permeability of the production zone however. In order to maximize the production rates and temperatures the well should be drilled to a depth that will encounter permeable beds. [Assumes that these are present] The well location should result in the intersection of the wellbore and fractured zone to obtain the required temperature and permeability at a depth of no more than 3,000 feet. Reasonable well production rates and water temperature should then be encountered from that point and deeper to a maximum anticipated depth of 4,000 feet.

Why assume that the production zone is 1000 ft+ thick

3. Injection Well

This well should be located within the influence of the geothermal resource so it can be used as a geothermal monitoring well during testing of the production well. This well will provide data that can then be used to estimate the geothermal reservoir characteristics and response during long term production conditions. Also, the well should be sited for later use as an injection well (in the zone directly above the geothermal production) or back up production well (by drilling deeper into the production zone).

H. DRILLING PROGNOSIS

The drilling of the production and injection wells will be primarily accomplished in the unconsolidated to semi-consolidated valley fill material. If it is necessary to drill the production well beyond 3,200 feet, the quartzite bedrock well be a limiting factor unless highly altered or fractured. The fill material just above the quartzite should be an excellent target zone. The rock types may present two problems for the well driller. The first will be the boulders and cobbles that might necessitate remedial measures (cementing) in order to drill through with a rotary rig. The second might be a tendency for the hole to cave. Light mud should control this problem although it may make the geothermal resource slightly more difficult to detect. Periodic temperature surveys will be taken in the borehole during drilling to minimize the difficulty of detecting the resource with mud in the hole.

A third problem must be anticipated concerning the resource itself. The production zone will probably be under a low confining pressure head (10-40 psig) and water above 120^0F can cause severe burns. Again, the use of a light mud base drilling fluid as well as shut-off valve and flow line installation during drilling will control this problem.

All aspects of the drilling should be well within the normal operation of water well drillers and current techniques.

I. <u>REFERENCES</u>

1. R.E. Mattick (USGS), "Thickness of Unconsolidated to Semi-Consolidated Sediments In Jordan Valley, Utah," USGS Prof. Paper 700-C, (1970).

2. A. W. Mavine and D. Price (USGS), "Geology and Ground-Water Resources of the Jordan Valley, Utah, "Utah Geological and Mineralogical Survey, Water-Resources Bulletin 7 (December 1964).

3. J. C. Mundorff (USGS), "Major Thermal Springs of Utah", Utah Geological and Minerlogical Survey, Water-Resources Bulletin 13 (September 1970).

4. Guidebook to the Geology of Utah, Number 8 collection of papers, "Geology of the Central Wasatch Mountains, Utah, "Utah Geological and Mineralogical Survey (1952).

5. Guidebook to the Geology of Utah, Number 18, collection of papers "The Wasatch Fault Zone in North Central Utah, "Utah Geological and Mineralogical Survey (1964).