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SUMMARY OF 1976 GEOTHERMAL DRILLING – WESTERN UNITED STATES

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In 1976 there were 52 wells and 13 deep observation holes drilled to explore for and develop geothermal resources in the States of California, Idaho, Nevada, Oregon, and Utah. This was an increase of 27% over the total number of locations drilled in 1975. Of the 52 wells drilled during 1976, 39 (75%) are now considered to have successfully found at least potentially commercial quantities of steam or hot water, 8 are otherwise suspended, and 5 were abandoned. Two new fields were discovered, in the Imperial Valley and Nevada, and four important extensions to production were made at The Geysers.

Table 1 summarizes the drilling activity by States and Table 2 by Operator. Included are all wells spudded during calendar year 1976. The total footage drilled was 437,752 feet, which represents an increase of 82,609 feet (23%) over the total footage drilled in 1975. As in 1975, the three operators most active in 1976 were Union, Aminoil, and Republic Geothermal, based on footage drilled.

CALIFORNIA

There was a significant increase in geothermal drilling in the Imperial Valley during 1976 (Figure 1).

At Westmorland, Republic Geothermal drilled the "Landers" #2 to 7507 feet, discovering a new geothermal field southwest of the Salton Sea (Niland) KGRA field. The new field discovery was soon confirmed by the successful drilling and completion of three deep step-out wells: the "Dearborn" #1 (8000 feet), "Landers" #1 (7705 feet), and "Kalin Farms" #1 (8490 feet). Maximum recorded temperatures were approximately 500°F., and short-term flow rates exceeded 40,000 B/D. Republic then drilled the "Dearborn" #2 (4564 feet) and "Landers" #3 (4650 feet) wells in a successful attempt to evaluate and produce from an intermediate-depth commercial reservoir. Long-term flow tests are now being conducted to further delineate the thermal, chemical, and flow parameters of the six Republic wells now drilled in the Westmorland field.

Union Oil completed two wells in the Braw area, the "Kruger" #1 (6793 feet) and "Jimin #1 (9618 feet). Both were successful, which bri the total number of potential commercial we in the Brawley area to five. Union is now a conducting long-term testing in conjunction w power plant design.

At East Mesa, Magma drilled on federal KG land immediately south of the Bureau of Recla ation wells. The two new wells, Magma "U #44-7 (7328 feet) and Magma "US" #48-7 (7 feet), were both successfully tested with bot hole temperatures exceeding 370°F. Meanwh at the Heber field, Chevron drilled the "GT #5 (7089 feet) as a deep observation hole Union drilled three observation holes and production wells, the "Thomson" #1 (7132 f and "Thomson" #2 (9701 feet). The two Un wells are reported to be commercial, extend confirmed production to the south and sou west.

At The Geysers field in Northern California series of development and extension wells w being drilled (Figure 2). Of the 16 developme wells drilled, Union completed 13 in the Ma Geysers area to supply PG&E Units 1-12 a Pacific Energy (now Thermogenics, Inc., a di sion of Hughes Aircraft Corp.) added one for U in Unit 15, a 55 mw. plant now under constru tion. The Shell "U.S. Geothermal" #C-5 and recompleted Aminoil "CA-1862" #37-21 we successful development wells drilled further the south.

Six wells were drilled in attempts to make gene ally modest extensions to the known product limits of The Geysers field. The McCulloch "Fra cisco" #1-5 (8970 feet) obtained 75,000 #/hr. dry steam at a location one mile north of pr viously proven production, and the Union "Phelps #1 (8317 feet), also drilled in Lake County, w apparently successful at an extension site on mile northeast of developed production. Com mercial extension wells were also completed a significant step-out distances of up to thre miles to the northwest by Aminoil with the "Wil horse" #5 (9327 feet) and "Aidlin" #1 (8629 fee

REGION	AREA	OPERATOR	WELLS	PROD.	SUSP.	ABD.	OBS.	FOOTAGE
Imperial	Westmorland	Republic Geothermal	6	6	0	0	0	40,916
Valley	Brawley	Union	2	2	0	0	0	16,411
	East Mesa	Magma Power	2	2	0	0	0	14,851
	Heber	Union	5	2	0	0	3	29,633
		Chevron	1	0	0	0	1	7,089
The Geysers	Main Geysers	Union	14	14	0	0	0	122,675
		Aminoil	2	2	0	0	0	20,967
		Pacific Energy	1	1	0	0	0	10,550
		McCulloch	1	1	0	0	0	10,153
	Castle Rock	Aminoil	3	1	2	0	0	21,963
		Shell	1	1	0	0	0	5,626
	Middletown	Aminoil	1	0	1	0	0	11,561
		Chevron	1	0	1	0	0	9,232
		Shell	1	0	0	1	0	8,250
	Cloverdale	Shell	1	0	0	1	0	10,431
	Mt. Konocti	Magma Power	1	0	1	0	0	6,660
	Calistoga	AMAX	3	0	0	0	3	5,868
Mono Co.	Long Valley	Republic Geothermal	1	0	1	0	0	6,920
Inyo Co.	Coso Hot Springs	Battelle Pac.NW Lab.	1	0	0	0	1	1,352
Churchill	Desert Peak	Phillips	2	2	0	0	0	7,342
County	Stillwater	Union	3	0	0	0	3	11,654
Lander Co.	Beowawe	Chevron	1	0	1	0	0	5,680
Klamath Co.	Klamath Hills	Thermal Power	1	0	0	1	0	5,842
Cassia Co.	Raft River	Idaho Nat.Eng.Lab.	2	2	0	0	0	8,991
Ada Co.	Boise	Idaho Nat.Eng.Lab.	2	0	0	0	2	3,188
Beaver Co.	Roosevelt	Phillips	1	1	0	0	0	7,513
		Thermal Power	2	2	0	0	0	7,362
Millard Co.	Cove Fort	Union	1	0	0	1	0	1,151
Iron Co.	Beryl Junction	McCulloch	2	0	1	1	0	17,921

TABLE #1. SUMMARY BY STATES, 1976 GEOTHERMAL DRILLING, WESTERN U. S.

Earlier in the year Aminoil had unfortunately been less successful in adding production in the southeast part of the field where the "Davies Estates" #2 (8231 feet) and #3 (10,240 feet) reportedly both found adequate temperatures but insufficient steam flow.

The five exploratory wildcat wells drilled at distances further from known production at The Geysers do not appear as yet to have found commercial production (Figure 3). The Magma "Watson" #1, located on the south flank of Mt. Konocti, was suspended at 5437 feet with mechanical hole problems. The Shell "Hilary Farms" #1 (6500 feet) and "Bounsall" #1 (8250 feet) were both abandoned, having found insufficient temperatures at the depths drilled. Chevron has suspended the "Dry Creek" #1 at 8597 feet awaiting further evaluation, and Aminoil suspended the "B-J" #1 after having drilled to 10,228 feet. Nearby, in Napa County, Amax drilled three temperature observation holes.

Along the Sierran front of eastern California is the Long Valley Caldera (Figure 4). The area has recently been the site of extensive USGS geothermal resource investigations, and in spring of 1976 Republic Geothermal drilled the "Long Valley" #66-29 to 6920 feet as the first deep test well within the caldera. Bottom-hole temperatures were disappointingly low, less than 200°F., and the outlook for the eastern part of the caldera now appears severely limited.

About 120 miles south of Long Valley is the Coso Hot Springs area. Battelle Pacific Northwest Laboratory, operating under an ERDA contract, continuously cored the "BDSH" #1 observation hole to 1352 feet in granitic basement as part of a continuing evaluation of the hot dry rock potential suspected to exist under the Naval Weapons Center. At a depth of 1000 feet the hole had a reported temperature of at least 300°F.

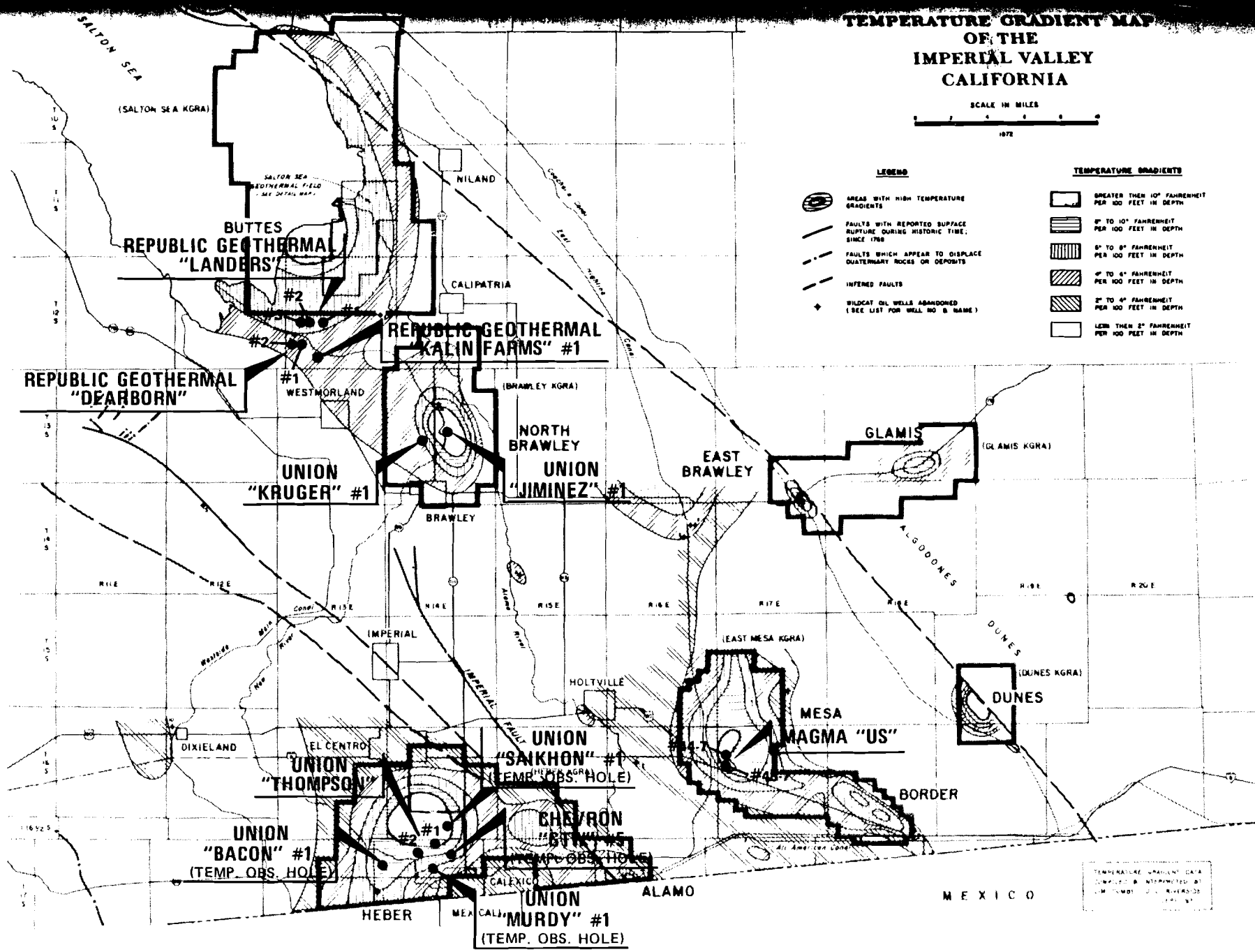
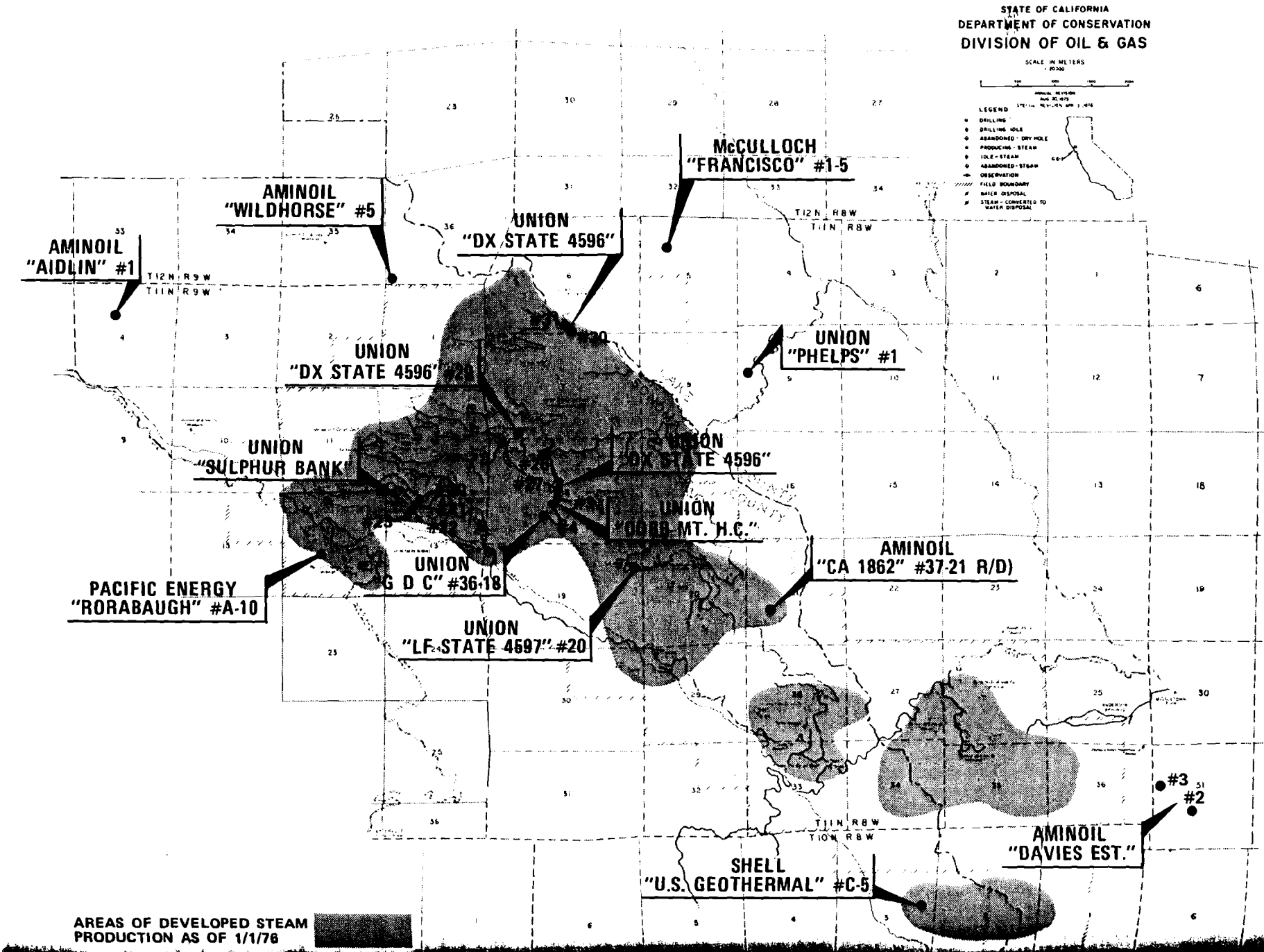


Figure 1, 1976 Geothermal Wells, Imperial Valley, California


STATE OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL & GAS
SCALE IN METERS
LEGEND
DRILLING
DRILLING HOLE
ABANDONED - DRY HOLE
PRODUCING - STEAM
IDLE - STEAM
ABANDONED - STEAM
OBSERVATION
FIELD BOUNDARY
WATER DISPOSAL
STEAM - CONVERTED TO WATER DISPOSAL
McCULLOCH "FRANCISCO" #1-5
AMINOIL "WILDHORSE" #5
UNION "DX STATE 4596"
AMINOIL "AIDLIN" #1
UNION "PHELPS" #1
UNION "DX STATE 4596" #28
UNION "SULPHUR BANK"
UNION "DX STATE 4596"
UNION "GEYSERS MT. H.C."
AMINOIL "CA 1862" #37-21 R/D)
UNION "G D C" #36-18
PACIFIC ENERGY "RORABAUGH" #A-10
UNION "LF STATE 4597" #20
#3
#2
AMINOIL "DAVIES EST."
SHELL "U.S. GEOTHERMAL" #C-5
T12N R9W
T11N R9W
T12N R8W
T11N R8W
T10N R8W
AREAS OF DEVELOPED STEAM PRODUCTION AS OF 1/1/76

NEVADA

In 1974 Phillips drilled the "Deserk Peak" 29-1 to a depth of 7662 feet at a location 5 miles southeast of Brady Hot Springs in Churchill County. After evaluation, Phillips returned in the fall of 1976 to drill the "Deserk Peak" #21-1 (4150 feet). This well is considered a commercial new field discovery, and the #21-2 confirmation well that immediately followed is reported to have a maximum temperature of 390°F. at a 3192 foot T.D. Additional drill sites are now being permitted. Twenty miles further southeast, Union was drilling three deep observation holes in the Stillwater area to depths of 2672 feet-5532 feet. A nearby 4237 foot well drilled in 1964 had a maximum temperature of 265°F. Elsewhere in Nevada, the "Rossi" #21-19 (5680 feet), was drilled and temporarily suspended by Chevron at Beowawe. The location is less than one mile southeast of their "Ginn" #1-13 drilled to 9563 feet in 1974.

OREGON

The one geothermal well drilled in 1976 was the Thermal Power "O'Connor Ranch" #1, located 12 miles south of Klamath Falls in the vicinity of shallow holes with 200°F. water at less than 300'. The "O'Connor" #1 was abandoned at 5842 feet after an unsuccessful attempt to recover lost drill pipe in the well.

IDAHO

The Idaho National Engineering Laboratory (INEL) continued exploration drilling in the Raft River Basin. The "RRGE" #2, originally drilled in 1975, was deepened from 5988 feet to 6543 feet, and the "RRGE" #3 was drilled in "birdfoot" fashion, meaning the original hole (5853 feet) and two directionally deviated lower redrills to 5532 feet and 5935 feet are all open to completion. The #3 well flows 800 gpm of 297°F. water. INEL also drilled two deep observation holes to 1222 feet and 1283 feet near Boise to help define the shallow intermediate-temperature geothermal resources of that area.

UTAH

Three additional development wells were successfully completed in the Roosevelt KGRA, site of a significant new field discovery in 1975. Phillips drilled #25-15 (7513 feet), their seventh geothermal well and sixth producer in that field. On nearby State leases within the same KGRA, Thermal Power completed the "Utah State" #14-2 (6108 feet) and #72-16 (1254 feet). Well #72-16, located near the controlling surface fault, hit steam at 300 feet, 700 feet and 1200 feet. Preliminary tests of #72-16 demonstrate a wellhead pressure of 355 psig and a temperature of 432°F. The indicated total mass flow rate is about 1 million #/hour.

OPERATOR	WELLS DRILLED	PRODUCIBLE	SUSPENDED	ABANDONED	OBSERVATION	TOTAL FOOTAGE DRILLED
Union	25	18	0	1	6	181,524
Aminoil	6	3	3	0	0	54,491
Republic Geothermal	7	6	1	0	0	47,836
McCulloch	3	1	1	1	0	28,074
Shell	3	1	0	2	0	24,307
Chevron	3	0	2	0	1	22,001
Magma	3	2	1	0	0	21,511
Phillips	3	3	0	0	0	14,855
Thermal Power	3	2	0	1	0	13,204
Idaho Nat. Eng. Lab.	4	2	0	0	2	12,179
Pacific Energy	1	1	0	0	0	10,550
Amax	3	0	0	0	3	5,868
Battelle Pac. NW Lab.	1	0	0	0	1	1,352
TOTALS:	65	39	8	5	13	437,752

TABLE #2, SUMMARY BY OPERATOR, 1976 GEOTHERMAL DRILLING, WESTERN U.S.

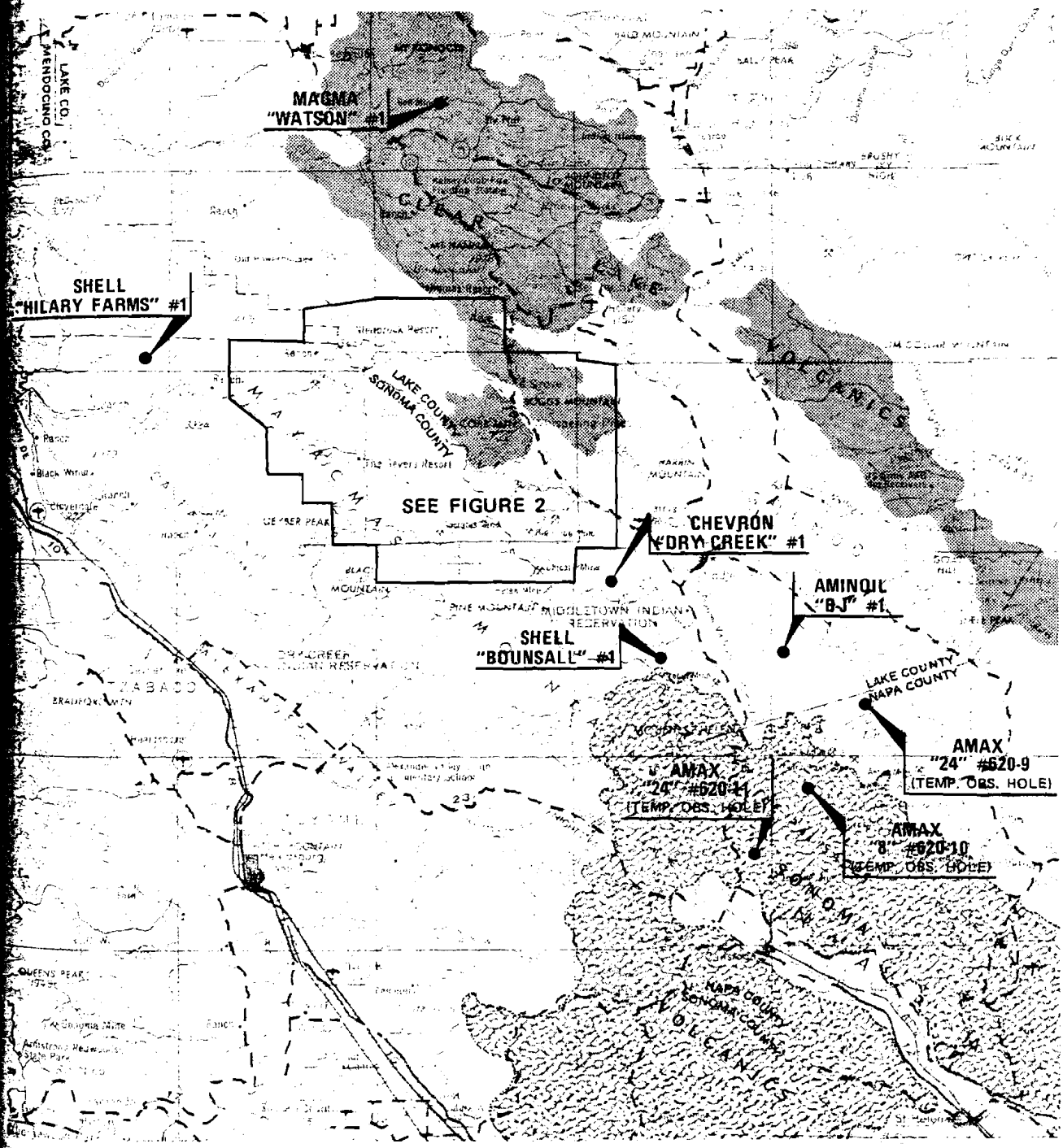


Figure 3, 1976 Geothermal Wells, The Geysers Region, California

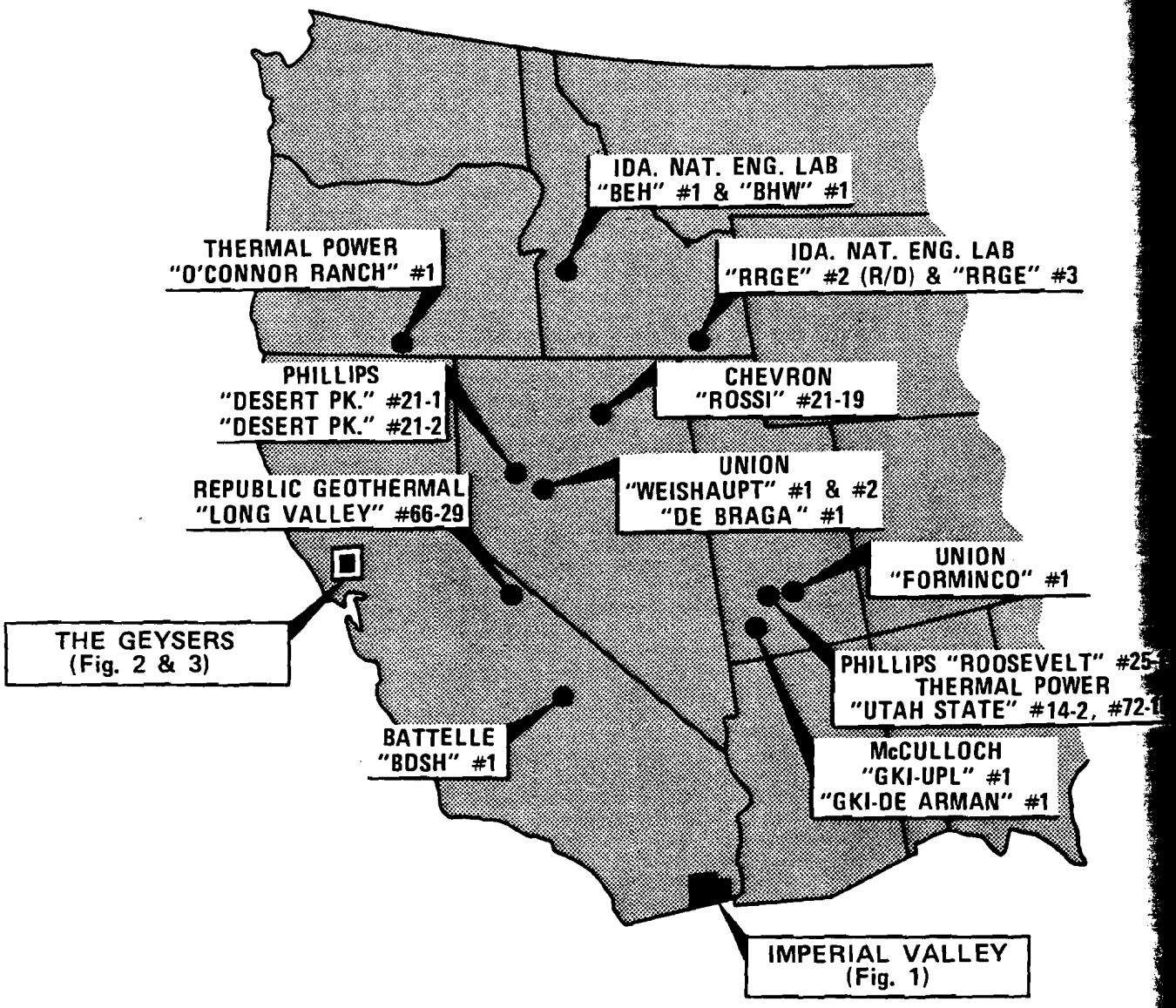


Figure 4, 1976 Geothermal Wells, Western United States

Union drilled the "Forminco" #1 at Cove Fort, about 18 miles east of Roosevelt. The well was finally aborted at 1151 feet and abandoned after having fought significant lost circulation and hydrogen sulphide problems. McCulloch drilled two wells to the south near Beryl Junction. The first was abandoned at 4986 feet and the "De Arman" #1 has been suspended indefinitely after reaching a total depth of 12,295 feet.

In summary, the geothermal industry demonstrated in 1976 a moderately increased drilling effort that achieved a healthy mix of development, production step-out, and exploratory wildcat wells in both proven and unproven provinces. The indicated success of 75% of the total deep wells drilled is still extremely high, especially considering nine unproven areas were explored. Hopefully this success ratio will remain high as exploration and drilling technologies evolve and improve.

Dr. Smith, Vice President-Exploration, received his education as a geologist at Middlebury College and Indiana University. After spending a decade as an explorationist with Standard Oil Company of California, he has been with Republic Geothermal for the past two years. Mr. Isselhardt received a M.A. (geology) at U.C. Berkeley and was active with Union Oil geothermal operations for five years before coming to Republic in 1976. Mr. Matlick, an exploration geologist-geochemist, joined Republic in 1975 after completing his M.S. in geology at Arizona State University.

ERDA ANNOUNCES NEW INSTRUMENT TO LOCATE GEOTHERMAL SOURCES

A new instrument for locating underground geothermal energy sources without drilling has been announced by the Energy Research and Development Administration. The instrument, a magnetometer developed by two California professors, can be used to explore depths of up to 20 kilometers and take measurements at depths of up to 50 kilometers, the ERDA said. The device was developed by John Clarke and Frank Morrison of UC Berkeley and the Lawrence Laboratory. The tool also may have a potential for detecting uranium and predicting earthquakes, ERDA said.

—Los Angeles Times, March 18, 1977