

REPORT GG

BRINE CHEMISTRY RESULTS

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36 p.

with Addendum A-C: ANALYTICAL DATA

16 p.

Appendix G

BRINE CHEMISTRY RESULTS

CHEMISTRY REPORT

State 2-14 Geothermal Well

Flow Test in June 1988

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CHEMISTRY REPORT
State 2-14 Geothermal Well
Flow Test in June 1988

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CHEMISTRY REPORT
State 2-14 Geothermal Well
Flow Test in June 1988

Section 1

SUMMARY AND CONCLUSIONS

The primary objective of the brine chemistry sampling program was to characterize the brine produced by the State 2-14 well during the flow test in June 1988.

Chemical sampling was supervised by Kennecott, and the primary chemical analyses were conducted for the Electric Power Research Institute (EPRI) by Combustion Engineering, Inc. using the EPRI Mobile Geothermal Chemistry Laboratory that was on site during the flow test.

Three types of sampling events were conducted during the flow test. Signature tests, measuring 64 chemical species, were conducted at each of the three rate steps to characterize the chemical and physical characteristics of the total well flow. Tracking tests were performed daily to observe changes in selected properties as a function of time. Special tests were conducted as needed to investigate flow streams or equipment of special interest.

This report focuses on the results of the signature and tracking tests for information needed to characterize the brine.

The brine chemistry results during the three rate steps are presented in Section 3. The following conclusions are readily drawn from these results:

- Total dissolved solids (TDS) increased for the second and third rate steps.

- Sodium and potassium increased 7 and 12 percent, respectively, but calcium increased 33 percent from the first to the third rate step.

The TDS concentration and the geothermometers, Na/K, Na/Ca and Ca/K, were examined for indications that various zones may be producing in different proportions as the well flow was varied during the flow test. The results for the June 1988 flow test were compared with similar indicators from the short flow test of the zone from 6,000 to 6,200 ft in December 1985 and the short flow test conducted shortly after well completion in March 1986.

The TDS concentration varied little during the flow test even though the smoothed flow rate varied over a range of 7:1. A slight increase in the TDS concentration apparently occurred as the well flow rate was increased for the second rate step. Initially, the TDS concentration was about 235,000 mg/kg, and it increased to about 250,000 mg/kg. No further significant changes were observed after this shift between the first and second rate steps.

During the flow test in June 1988, the Na/Ca and Ca/K ratios changed considerably (-20 and +19 percent respectively) while the Na/K ratio changes were less dramatic (+8 percent from the first to second rate steps and -4 percent from the first to the third). These changes in the geothermometers, Na/K, Na/Ca and Ca/K, lead to the following conclusions:

- More than one zone is probably producing a significant portion of the total well flow.
- The various zones may be producing different proportions of the total flow as the well flow is increased or decreased.

Comparison of the Na/K, Na/Ca and Ca/K ratios for the second rate step during the June 1988 flow test with the corresponding ratios for the March 1986 test shows very little difference. Therefore, the producing zones and their relative contributions may have been essentially the same for the two test conditions.

The information for the December 1985 test and the data for the flow test in June 1988 permit comparison of fluids produced from 6,000 to 6,200 ft depth

with fluids that are probably from several zones. The fluid produced by the zone from 6,000 to 6,200 ft in December 1985 appears higher in potassium and roughly equal in sodium, calcium, and TDS concentrations to the fluids produced in June 1988. Curiously, these generalizations apply more closely for the second and third rate steps than for the first; one hypothesis for this is that the higher well flow rates may favor production from the relatively shallow zone from 6,000 to 6,200 ft.

The chemistry and static (non-flowing) temperatures for the State 2-14 well were compared with those for eleven other wells in the vicinity for which data are available as non-proprietary information.

In general the wells to the southwest of State 2-14 have lower TDS concentrations. Although depth has often been reported as an important factor with respect to TDS, the River Ranch No. 1 and Sportsman No. 1 wells, which are near State 2-14, produce fluid with relatively high TDS concentration from relatively shallow production zones starting at about 4,000 ft depth.

State 2-14 and the wells near it tend to have relatively low values of Na/Ca ratio. The wells in the vicinity of State 2-14 tend to have lower Na/K ratios than does State 2-14; this may be due at least in part to greater depth of its production zones. Generalizations concerning Ca/K are not apparent.

Because of virtually identical sodium, potassium and calcium concentrations and similar depth of the production zones, it appears that the geothermal fluid produced from the zone between 6,000 to 6,200 ft depth in the State 2-14 well and the fluid produced by the nearby Hudson No. 1 well quite likely arise from the same source.

Temperatures in the State 2-14 well seem to track those in the nearby River Ranch No. 1 well from 3,000 to 5,000 ft; however, at 6,000 and 7,000 ft, the temperatures are 23 and 20 °F higher, respectively, in the River Ranch No. 1 well.

The temperatures in the State 2-14 well are 120 to 130 °F lower than those in the Elmore No. 1 well for all depths from 3,000 to 7,000 ft. Likewise, the temperatures in the State 2-14 well are 80 to 120 °F lower than those in the IID Nos. 1 and 2 wells from 3,000 ft to the total depths for the IID wells, 5,213 ft for IID No. 1 and almost 6,000 ft for IID No. 2.

Section 2

OVERVIEW OF BRINE CHEMISTRY SAMPLING PROGRAM

The primary objective of the brine chemistry sampling program was to characterize the brine produced by the State 2-14 well during the flow test in June 1988.

Chemical sampling was supervised by Kennecott, and the primary chemical analyses were conducted for the Electric Power Research Institute (EPRI) by Combustion Engineering, Inc. using the EPRI Mobile Geothermal Chemistry Laboratory that was on site during the flow test.

Three types of sampling events were conducted during the flow test. Signature tests were conducted three times to characterize the chemical and physical characteristics of the total well flow. Tracking tests were performed daily to observe changes in selected properties as a function of time. Special tests were conducted as needed to investigate flow streams or equipment of special interest.

Signature Tests. The flow test program was planned to stabilize flow in three rate steps. Sampling for signature analyses was conducted at each of the three rate steps as shown in Figure 2-1. In each case, the sampling was done well after the flow had stabilized, usually towards the end of each rate step.

For the signature tests, samples of separated brine and separated steam were collected from the locations shown in Figure 2-2. Characterizing the total well flow involves combining measurements of both steam and brine.

The signature tests include the measurement of 64 separate chemical species. Raw condensate samples were collected to measure pH, conductivity, Eh, dissolved oxygen, anions, and carbonate. Acidified samples (1 percent nitric acid) were collected for analysis of 30 metals by inductively coupled argon

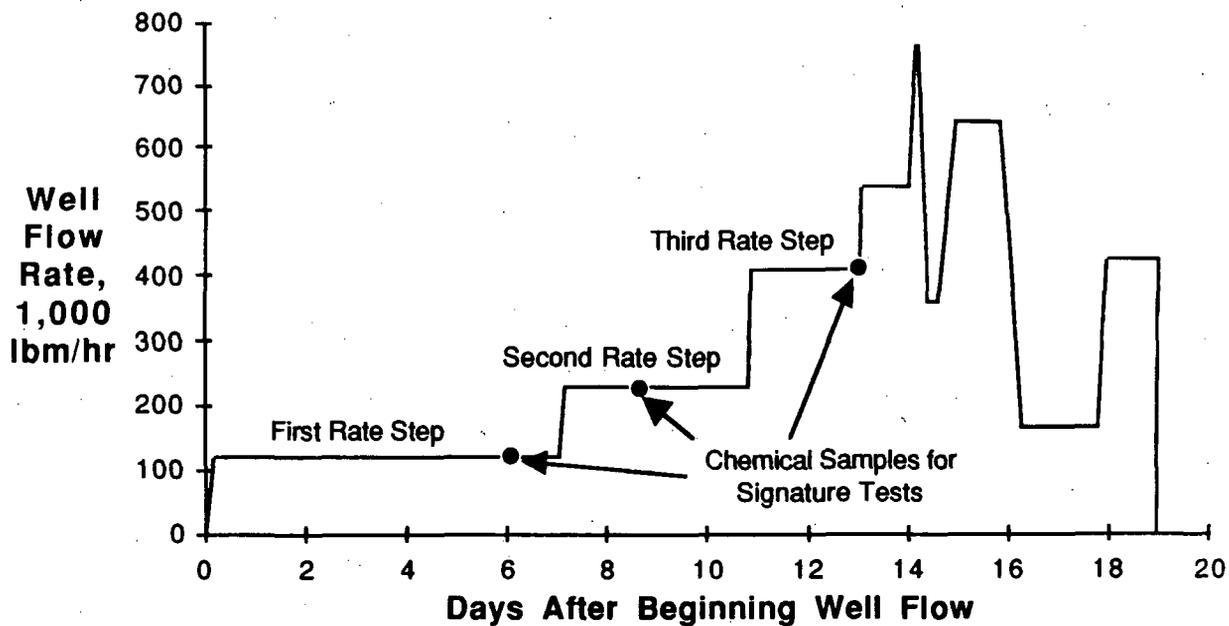


Figure 2-1 Smoothed Flow Curve with Times Shown for Collection of Samples for Signature Tests

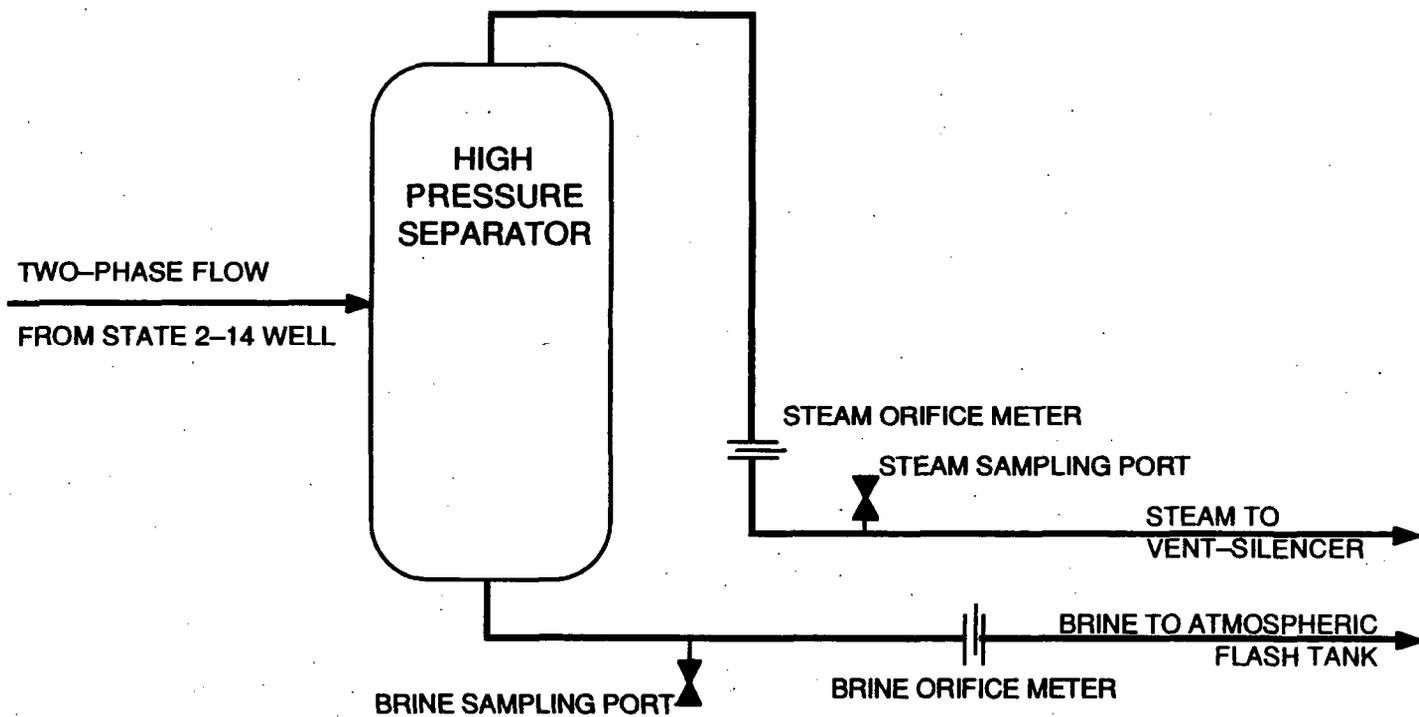


Figure 2-2 Sampling Port Locations

plasma spectrophotometry. Trapping solutions were used to trap and measure hydrogen sulfide and carbon dioxide. Noncondensable gases were collected at approximately atmospheric pressure and ambient temperature for analysis by gas chromatography.

Tracking Tests. Tracking samples were collected daily. Raw samples of separated brine were taken for immediate measurement of pH, conductivity, Eh, dissolved oxygen, and chloride. Acidified samples were collected for analysis of 30 metals by inductively coupled argon plasma spectrophotometry.

Special Tests. Tests for total suspended solids were conducted to provide data to help estimate the rate of sludge accumulation in the brine pond.

This report focuses on the results of the signature and tracking tests for information needed to characterize the brine produced by the State 2-14 well. Section 3 presents the results of the signature tests for each flow rate step; Section 4 explores the reservoir conditions inferred from the brine chemistry; and Section 5 compares the State 2-14 well with others in the area.

Section 3

CHEMISTRY ANALYSES FOR EACH FLOW RATE STEP

The signature test results (Addenda A and B) reported by Combustion Engineering, Inc., the operating contractor for the EPRI Mobile Geothermal Chemistry Laboratory, were converted to a mass ratio basis (i.e., mg of component per kg of total well flow) for presentation in this section. As appropriate, one of the following procedures was used to convert the reported results and arrive at a mass ratio:

- **Noncondensable Gases.** The concentration of each noncondensable gas (NCG) component is stated in Addendum A as mg of component per kg of steam downstream of the separator. Multiplying these results by the mass fraction of steam (ratio of steam flow rate to total well flow rate) converts them to mg of NCG per kg of total well flow. This assumes that the amount of NCG dissolved in the separated brine is negligible.
- **Dissolved Components.** The concentration of each dissolved component is stated in Addenda A and B as mg of component per liter of separated brine (cooled to ambient temperature). These results were first converted to mg of component per kg of separated brine by dividing by the density of the separated brine at ambient temperature. A value of 1.2 kg/l was used throughout as an average value for the density of separated brine.

The concentrations in mg of component per kg of separated brine were then multiplied by the mass fraction of separated brine (ratio of separated brine flow rate to total well flow rate) to convert to mg of component per kg of total well flow.

This procedure assumes that carryover of dissolved components in the steam is insignificant. Carryover is not zero, but compared to the total, it is extremely small.

Carbonate and sulfide were converted using this procedure even though the flash/separator conditions (i.e., the carbon dioxide and hydrogen sulfide in the steam) could affect the result; therefore, these ions should be considered as only rough indications.

- **Ammonia.** Significant amounts of ammonia appear in both the steam and the separated brine. The ammonia in the total well flow was calculated by summing the ammonia in each stream. That is, mg/kg of ammonia in the total well flow equals 1) the mg/kg of ammonia in the brine multiplied by the mass ratio of separated brine plus 2) the mg/kg of ammonia in the steam multiplied by the mass ratio of steam. Since ammonia is reported in Addendum A as mg of ammonium, the reported concentration is multiplied by the ratio of weight of ammonia/weight of ammonium to arrive at the mg of ammonia.

The brine chemistry results during the three rate steps appear in Table 3-1. The following observations are relevant from an initial inspection of these results:

- Total dissolved solids (TDS) increased for the second and third rate steps. This variation of TDS is examined and discussed in more detail in Section 4.
- Sodium varied over a narrow range from 49,829 to 53,151 mg/kg, potassium also varied over a narrow range from 13,152 to 15,116 mg/kg, but calcium experienced a wider variation from 23,128 to 30,723 mg/kg. As for TDS, these results are explored further in Section 4.
- Chromium and copper varied over ranges of more than 2:1. Chromium increased from 0.081 mg/kg to 0.204 mg/kg, and copper increased from 1.60 mg/kg to 3.68 mg/kg from the first to the third rate step.
- Gold is reported as 11.3 to 12.8 mg/kg. If this were true, the well could be a real bonanza. However, this result is suspect. First, gold is usually 100

times less abundant in geothermal brine in the Imperial Valley. Furthermore, . . .

Noncondensable gas content and composition results appear in Tables 3-2 and 3-3. Noncondensable gas content is rather high. Concentrations of the half-percent magnitude (3,928 to 5,731 mg/kg) reported here would force extensive and probably expensive measures in the construction and operation of a power plant using the brine. These results should be checked by additional testing before design of a power plant to use brine from this well.

Carbon dioxide comprises more than 98 percent of the noncondensable gases; this is commonly the case for geothermal fluids.

Hydrogen sulfide is reported as 22, 2.2, and 6 mg/kg for the three rate steps. Additional testing to quantify the hydrogen sulfide is appropriate before application of this brine for power production. This should be done to assess whether and to what degree hydrogen sulfide abatement may be needed.

Table 3-1

Brine Chemistry
State 2-14 Geothermal Well
Flow Test in June 1988

	<u>First Rate Step</u> Concentration in Total Well Flow mg/kg	<u>Second Rate Step</u> Concentration in Total Well Flow mg/kg	<u>Third Rate Step</u> Concentration in Total Well Flow mg/kg
Aluminum	0.140	0.201	0.198
Antimony	0.442	0.661	0.696
Arsenic	5.77	6.49	11.39
Barium	114	72	94
Boron	399	Not reported	Not reported
Cadmium	0.463	0.533	0.443
Calcium	23,128	30,143	30,723
Cobalt	0.032	0.028	0.034
Chromium	0.081	0.019	0.204
Copper	1.60	2.64	3.68
Gold	12.8	11.3	12.0
Iron	1,297	1,314	1,448
Lead	78	73	70
Lithium	157	164	174
Magnesium	14.6	13.7	13.4
Manganese	1,177	1,123	1,132
Mercury	< 0.001	< 0.001	< 0.001
Molybdenum	0.024	0.015	0.020
Nickel	0.018	0.032	0.032
Potassium	13,526	13,152	15,116
Selenium	< 0.001	< 0.001	0.001
Silicon	Not reported	127	117
Silver	0.144	0.166	0.190
Sodium	49,829	52,537	53,151
Strontium	339	326	371
Tin	<0.010	<0.060	<0.060
Titanium	<0.010	<0.010	<0.010
Tungsten	3.01	3.21	3.25
Vanadium	0.266	0.338	0.351
Zinc	421	402	459
Carbonate	Not reported	142	260
Chloride	144,000	149,000	150,000
Sulfate	77	Not reported	Not reported
Sulfide	5	4	65
TDS	235,000	249,000	253,000
NCG, mass %	0.57	0.39	0.40*
Ammonia, mg/kg	375	Not reported	Not reported
Well flow rate, lbm/hr	127,000	227,000	402,000

* From 6/20/88 with 435,000 lbm/hr well flow rate
NCG analysis data not available for third rate step

Table 3-2

Noncondensable Gas Content
 State 2-14 Geothermal Well
 Flow Test in June 1988

	<u>First Rate Step</u> Concentration in Total Well Flow mg/kg	<u>Second Rate Step</u> Concentration in Total Well Flow mg/kg	<u>Sample on 6/20/88*</u> Concentration in Total Well Flow mg/kg
Carbon dioxide	5,642	3,897	4,005
Hydrogen	3.1	0.55	0.77
Hydrogen sulfide	22	2.2	6
Nitrogen	8.6	5.5	15
Methane	12.7	7.3	6.0
Other hydrocarbons	43	16	8.86
Total NCG	5,731	3,928	4,041
Well flow rate, lbm/hr	127,000	227,000	435,000

*NCG analysis data not available for third rate step

Table 3-3

Noncondensable Gas Composition
 State 2-14 Geothermal Well
 Flow Test in June 1988

	<u>First Rate Step</u> Concentration mass % of NCG	<u>Second Rate Step</u> Concentration mass % of NCG	<u>Sample on 6/20/88*</u> Concentration mass % of NCG
Carbon dioxide	98.44	99.21	99.10
Hydrogen	0.05	0.01	0.02
Hydrogen sulfide	0.38	0.06	0.14
Nitrogen	0.15	0.14	0.38
Methane	0.22	0.18	0.15
Other hydrocarbons	0.75	0.40	0.22
Total NCG	100.00	100.00	100.00
Well flow rate, lbm/hr	127,000	227,000	435,000

*NCG analysis data not available for third rate step

Section 4

RESERVOIR CHEMISTRY

The chemical composition of the fluids produced during the flow test may yield information about whether various potential production zones are produced in different proportions as the well flow rate is varied through a range. Nine possible production zones were encountered during the drilling process at 2,619 to 3,160; 5,450 to 5,460; 6,110 to 6,130; 6,635 to 6,650; 8,090 to 8,100; 8,580; 8,950; 9,095 to 9,125; and 10,475 ft (GeothermEx, 1986). A casing was cemented in place to a depth of 6,000 ft, preventing the two zones at lesser depths from producing. However, with uncemented liner below 6,000 ft, the seven deeper zones are all possible sources of geothermal fluid with composition and temperature probably different for the various zones.

The TDS concentration and the geothermometers, Na/K, Na/Ca and Ca/K, were examined for indications that various zones may be producing in different proportions as the well flow was varied during the flow test. The results for the June 1988 flow test were compared with similar indicators from the flow test of the zone from 6,000 to 6,200 ft in December 1985 and the flow test conducted shortly after well completion in March 1986.

Total Dissolved Solids. The TDS concentration is plotted in Figure 4-1 as a function of time for the June 1988 flow test. The TDS data from the three rate steps is supplemented in this plot with estimates of TDS concentration from the tracking tests. The chloride concentration was measured in the tracking tests, and TDS concentration was calculated from the measured chloride content. The ratio of TDS to chloride is virtually constant for highly saline geothermal wells in the Imperial Valley. For the signature test results, this ratio varies from 1.63 to 1.69 for the three rate steps. Therefore, a value of 1.66 was used to estimate TDS for plotting Figure 4-1.

The TDS varied little during the flow test even though the smoothed flow rate varied over a range of 7:1.

A slight increase in the TDS concentration apparently occurred as the well flow rate was increased for the second rate step. Initially, the TDS concentration was about 235,000 mg/kg, and it increased to about 250,000 mg/kg. No further significant changes were observed after this shift between the first and second rate steps.

Figure 4-2 shows the TDS concentration as a function of instantaneous flow rate at the time a brine sample was taken for chemical analysis. This perspective of the TDS-flow rate information leads to the same conclusion as indicated above. For well flow rate somewhat greater than 100,000 lbm/hr, the TDS concentration was about 235,000 mg/kg; for flow rates greater than 200,000 lbm/hr, the TDS concentration was about 250,000 mg/kg.

Geothermometers. Table 4-1 shows the values for the geothermometers, Na/K, Na/Ca and Ca/K, for the three rates steps and for earlier tests in March 1986 and December 1985.

The short flow test in December 1985 was conducted with the well drilled to a depth of about 6,200 ft with casing installed and cemented to 6,000 ft. Thus it was a test of the zones from 6,000 to 6,200 ft, primarily the zone from 6,110 to 6,130 ft.

The short flow test in March 1986 was conducted shortly after completion of the well to a depth of 10,564 ft. At that time, the well had a cemented casing from the surface to a depth of 6,000 ft and an uncemented liner from 5,748 to 10,148 ft. Thus, any zone from 6,000 ft to bottomhole could have contributed to the flow.

During the flow test in June 1988, the sodium and potassium increased slightly from the first to the third rate step (sodium: 7 percent; potassium: 12 percent). However, calcium increased by 33 percent. Thus, the Na/Ca and Ca/K ratios changed considerably (-20 and +19 percent respectively) while the Na/K ratio

changes were less dramatic (+8 percent from the first to second rate steps and -4 percent from the first to the third).

These changes in the geothermometers, Na/K, Na/Ca and Ca/K, lead to the following conclusions:

- More than one zone is probably producing a significant portion of the total well flow.
- The various zones may be producing different proportions of the total flow as the well flow is increased or decreased.

Comparison of the Na/K, Na/Ca and Ca/K ratios for the second rate step during the June 1988 flow test with the corresponding ratios for the March 1986 test shows very little difference. Therefore, the producing zones and their relative contributions may have been essentially the same for the two test conditions.

The information for the December 1985 test and the data for the flow test in June 1988 permit comparison of fluids produced from 6,000 to 6,200 ft depth with fluids that are probably from several zones. The fluid produced by the zone from 6,000 to 6,200 ft in December 1985 appears higher in potassium and roughly equal in sodium, calcium, and TDS concentrations to the fluids produced in June 1988. Curiously, these generalizations apply more closely for the second and third rate steps than for the first; one hypothesis for this is that the higher well flow rates may favor production from the relatively shallow zone from 6,000 to 6,200 ft.

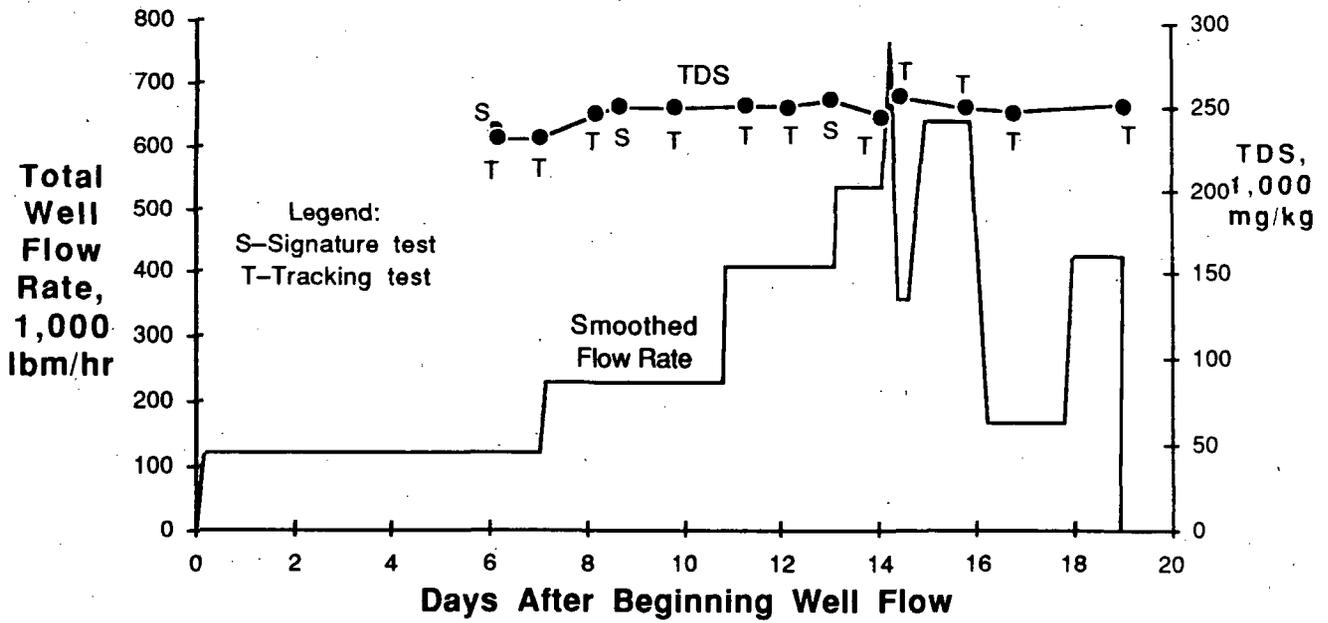


Figure 4-1 Total Dissolved Solids During Flow Test

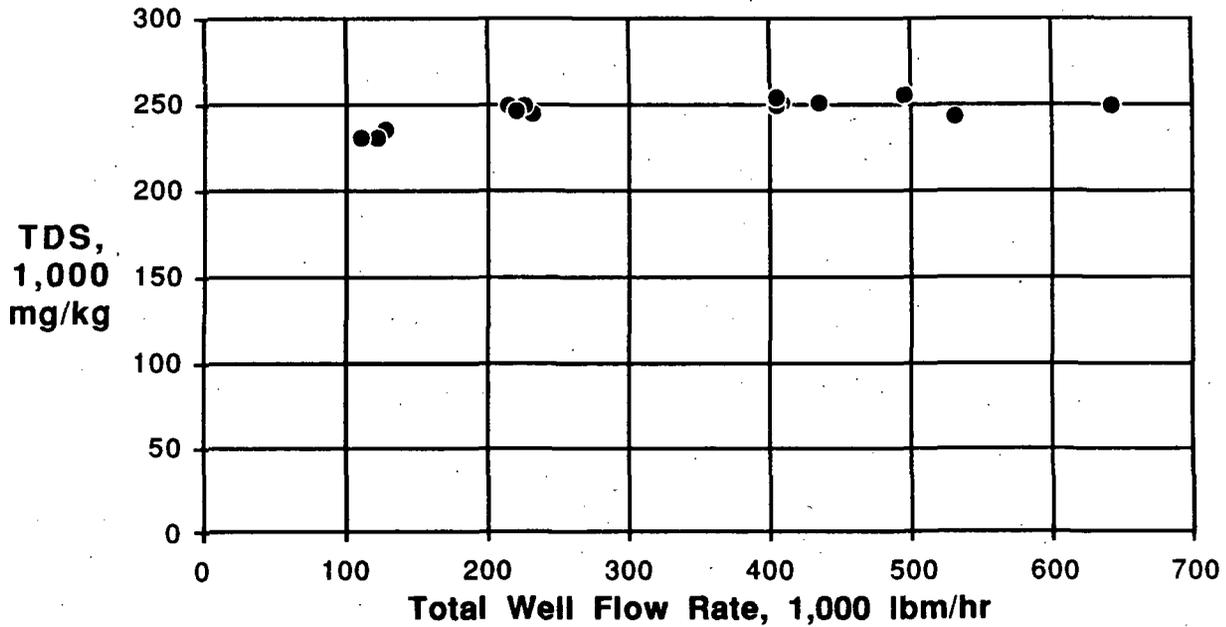


Figure 4-2 Variation of Total Dissolved Solids with Flow Rate

Table 4-1

Geothermometers
State 2-14 Geothermal Well
Flow Test in June 1988

	<u>First Rate Step</u>	<u>Second Rate Step</u>	<u>Third Rate Step</u>	<u>Flow Test in Mar 1986</u>	<u>Flow Test in Dec 1985</u>
Sodium (Na), mg/kg	49,829	52,537	53,151	Not available	52,661*
Potassium (K), mg/kg	13,526	13,152	15,116	Not available	16,502*
Calcium (Ca), mg/kg	23,128	30,143	30,723	Not available	26,515*
Na/K	3.68	3.99	3.52	4.09**	3.19
Na/Ca	2.15	1.74	1.73	1.86**	1.99
Ca/K	1.71	2.29	2.03	2.20**	1.61
TDS, mg/kg	235,000	249,000	253,000	251,000**	255,000*
Total well flow, lbm/hr	127,000	227,000	402,000	?	100,000 (approximate)

*Data from Michels, 1986

**Based on data from Addendum C

Section 5

COMPARISON OF CHEMISTRY AND TEMPERATURES FOR STATE 2-14 WELL WITH OTHER WELLS IN THE AREA

This section compares the chemistry and static (non-flowing) temperatures for the State 2-14 well with eleven other wells in the vicinity for which data are available as non-proprietary information. Although these eleven wells are not the complete group of wells in the vicinity, they do represent a reasonable data base for comparison.

Chemistry. Table 5-1 lists chemical composition data for the State 2-14 well (for the third rate step) and the eleven others shown in Figure 5-1. Comparing the order of listing in Table 5-1 with the locations in Figure 5-1 shows that the wells are listed left to right in Table 5-1 in roughly a southwest-to-northeast order. Additional, information about the relative depths of the wells is shown in Figure 5-2. Figure 5-2 uses the same left-to-right order as for Table 5-1.

TDS. In general the wells in the northeast part of this area have higher TDS concentrations. Although depth has often been reported as an important factor with respect to TDS, the River Ranch No. 1 and Sportsman No. 1 wells produce fluid with relatively high TDS concentration from relatively shallow production zones starting at about 4,000 ft depth.

Sodium, Potassium and Calcium. The wells in the northeast part of this area tend to have lower Na/K ratio, except for the State 2-14 well; this may be due at least in part to the greater depth of its production zones. Likewise, the wells in the northeast part of this area tend to have lower values of Na/Ca ratio.

Generalizations concerning Ca/K are not apparent. For example, the relatively deep State 2-14 well at the northeast end of this group of wells has the same value of Ca/K as does the shallow Magmamax No. 1 well at the southwest end of the group. Curiously, the River Ranch No. 1 well, near State 2-14, has

approximately the same value for Ca/K as does the Woolsey No. 1 well which is near the Magmamax No. 1 well. In both cases, the River Ranch and Woolsey wells resemble each other more, with regard to Ca/K, than they do their neighbors, State 2-14 and Magmamax No. 1 respectively.

The sodium, potassium and calcium concentrations for the fluids produced during the December 1985 test of the State 2-14 well and those for the Hudson No. 1 well, about one-half mile away, are strikingly similar as shown below:

	Hudson <u>No. 1</u>	State <u>2-14</u>
Sodium, mg/kg	52,250	52,661
Potassium, mg/kg	16,500	16,502
Calcium, mg/kg	26,917	26,515
Na/K	3.17	3.19
Na/Ca	1.94	1.99
Ca/K	1.63	1.61

In December 1985, an interval between 6,000 and 6,200 ft of the State 2-14 well was tested, and the production zone in the Hudson No. 1 well is at about 6,000 ft. Thus, the same stratum may be involved in the production from both.

However, the TDS concentrations reported in the two cases are considerably different: 273,000 mg/kg for Hudson No. 1 and 255,000 mg/kg for State 2-14. An anion-cation check of the two data sets revealed that the report for Hudson No. 1 shows apparent excess chloride of about 30,000 mg/kg, and the data set for State 2-14 implies an apparent 10,000 mg/kg excess chloride. Therefore, the TDS concentrations in the two cases could be essentially the same. Subtracting the calculated excess chloride quantities from the reported TDS concentrations yields virtually equal values for TDS concentrations: 243,000 mg/kg for Hudson No. 1 and 245,000 mg/kg for State 2-14.

Therefore, the geothermal fluid produced from the zone between 6,000 to 6,200 ft depth in the State 2-14 well and the fluid produced by the Hudson No. 1 well quite likely arise from the same source.

Temperatures. Figures 5-5 through 5-9 show well locations and static temperatures at depths from 3,000 to 7,000 ft.

Temperatures in the State 2-14 well seem to track those in the nearby River Ranch No. 1 well from 3,000 to 5,000 ft. At 6,000 and 7,000 ft, the temperatures are 23 and 20 °F higher, respectively, in the River Ranch No. 1 well.

The temperatures in the State 2-14 well are 120 to 130 °F lower than those in the Elmore No. 1 well for all depths from 3,000 to 7,000 ft. Likewise, the temperatures in the State 2-14 well are 80 to 120 °F lower than those in the IID Nos. 1 and 2 wells from 3,000 ft to the total depths for the IID wells, 5,213 ft for IID No. 1 and almost 6,000 ft for IID No. 2.

Table 5-1

Brine Chemistry of Geothermal Wells in the Vicinity of State 2-14
(mg/kg of total well flow)

	Sinclair No. 4	Sinclair No.3	Magmamax No. 1	Woolsey No. 1	Elmore No. 1	State No. 1	IID No. 2	IID No. 1	Sportsman No. 1	River Ranch No. 1	State 2-14	Hudson No. 1
Ammonia	—	283	304	254	342	—	—	341	—	—	375	—
Arsenic	8	8	—	—	—	—	—	10	—	—	11	—
Barium	—	—	—	—	—	—	208	196	—	167	94	—
Boron	633	450	117	121	—	158	325	325	124	—	399	—
Calcium	22,492	12,125	17,583	13,250	26,083	17,667	24,000	23,333	28,725	31,667	30,723	26,917
Chloride	128,825	78,042	109,417	95,667	153,333	105,833	129,167	129,167	167,500	173,333	150,000	173,333
Copper	—	—	0.8	1	—	2	3	7	—	—	4	—
Iron	—	—	233	121	3,833	1,000	1,667	1,742	3,500	1,750	1,448	1,667
Lead	34	67	39	24	74	67	67	70	—	81	70	—
Lithium	239	41	42	54	233	150	175	179	125	250	174	267
Magnesium	613	650	92	142	150	23	8	45	15	183	13	—
Manganese	850	342	529	363	825	792	1,142	1,250	—	1,583	1,132	1,833
Potassium	12,425	6,517	8,667	7,500	18,917	11,667	13,750	14,583	20,000	18,583	15,116	16,500
Silicon	75	—	200	125	—	—	333	333	4	—	117	—
Silver	—	—	0.3	—	—	1	—	1	—	—	0.19	—
Sodium	48,700	30,283	42,750	36,083	53,500	39,833	44,167	42,000	58,333	57,167	53,151	52,250
Strontium	358	300	—	296	608	—	367	500	—	700	371	650
Zinc	—	—	183	92	—	417	417	658	—	—	459	—
TDS	215,000	129,000	180,000	154,000	258,000	178,000	216,000	215,000	278,000	285,000	253,000	273,000
pH	5.3	5.3	5.6	6.0	—	—	—	5.2	—	—	5.3	—

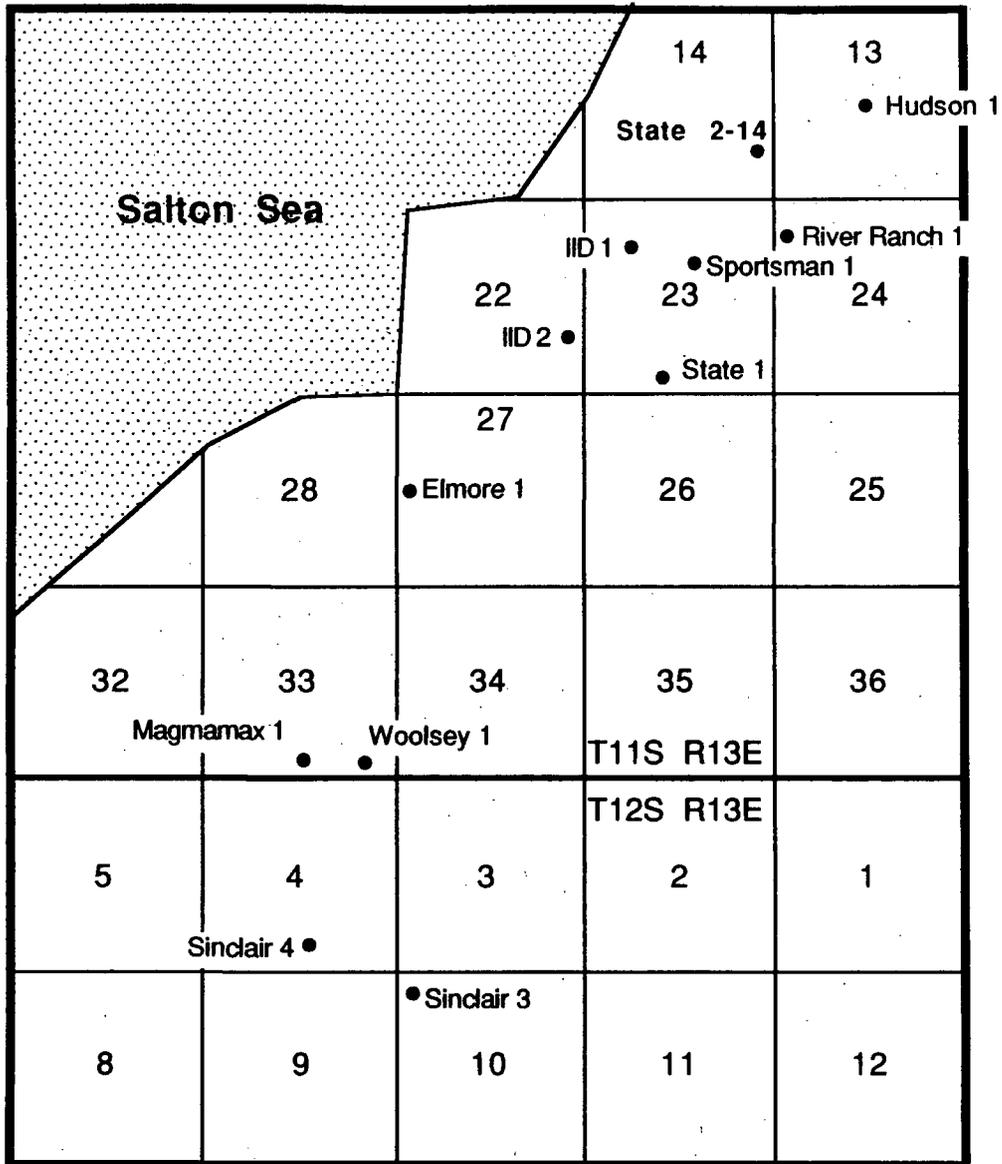


Figure 5-1 Locations of Wells Compared with State 2-14

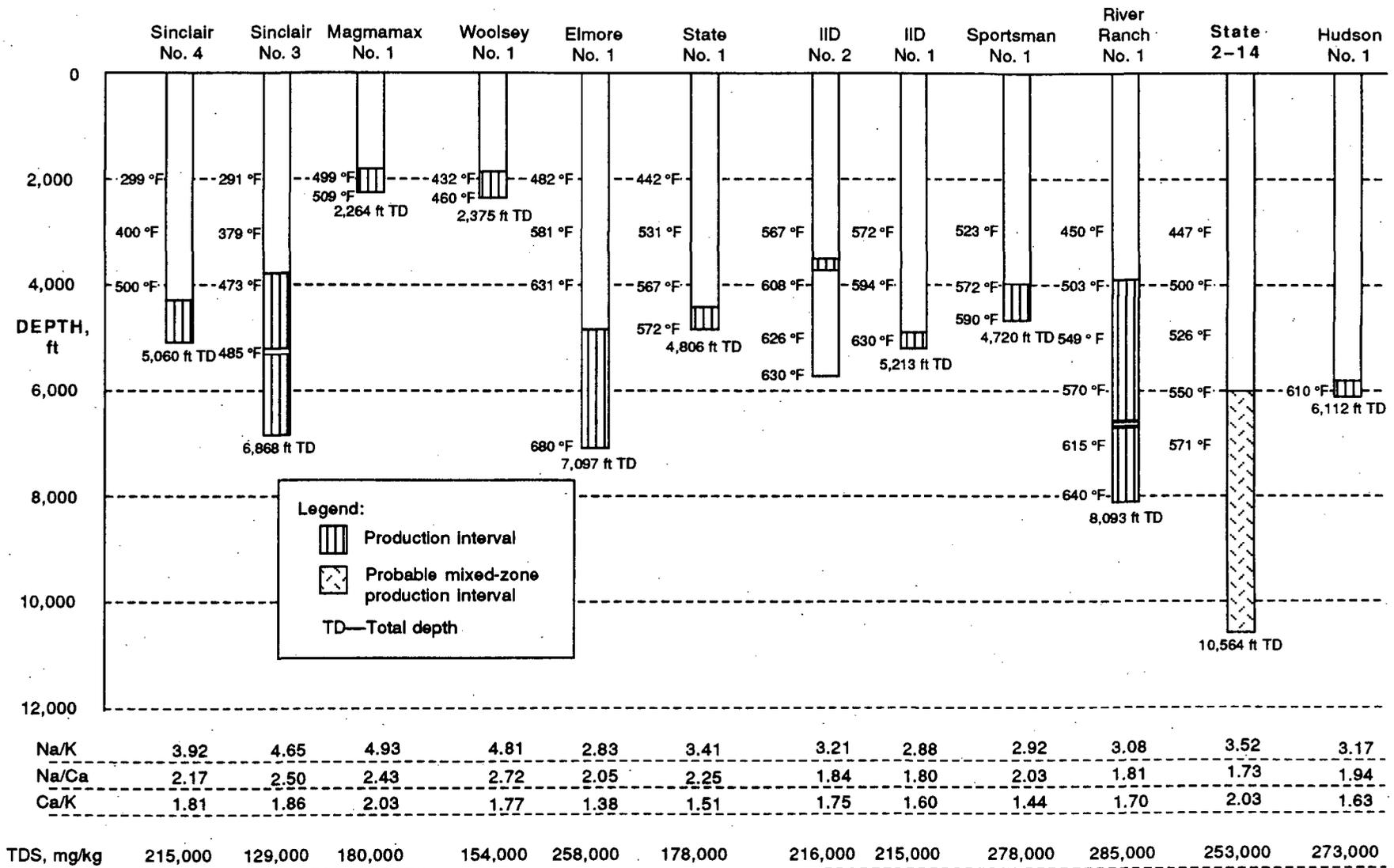


Figure 5-2 Characteristics of Geothermal Wells in the Vicinity of State 2-14

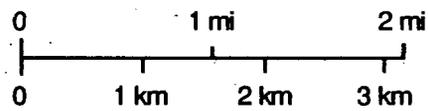
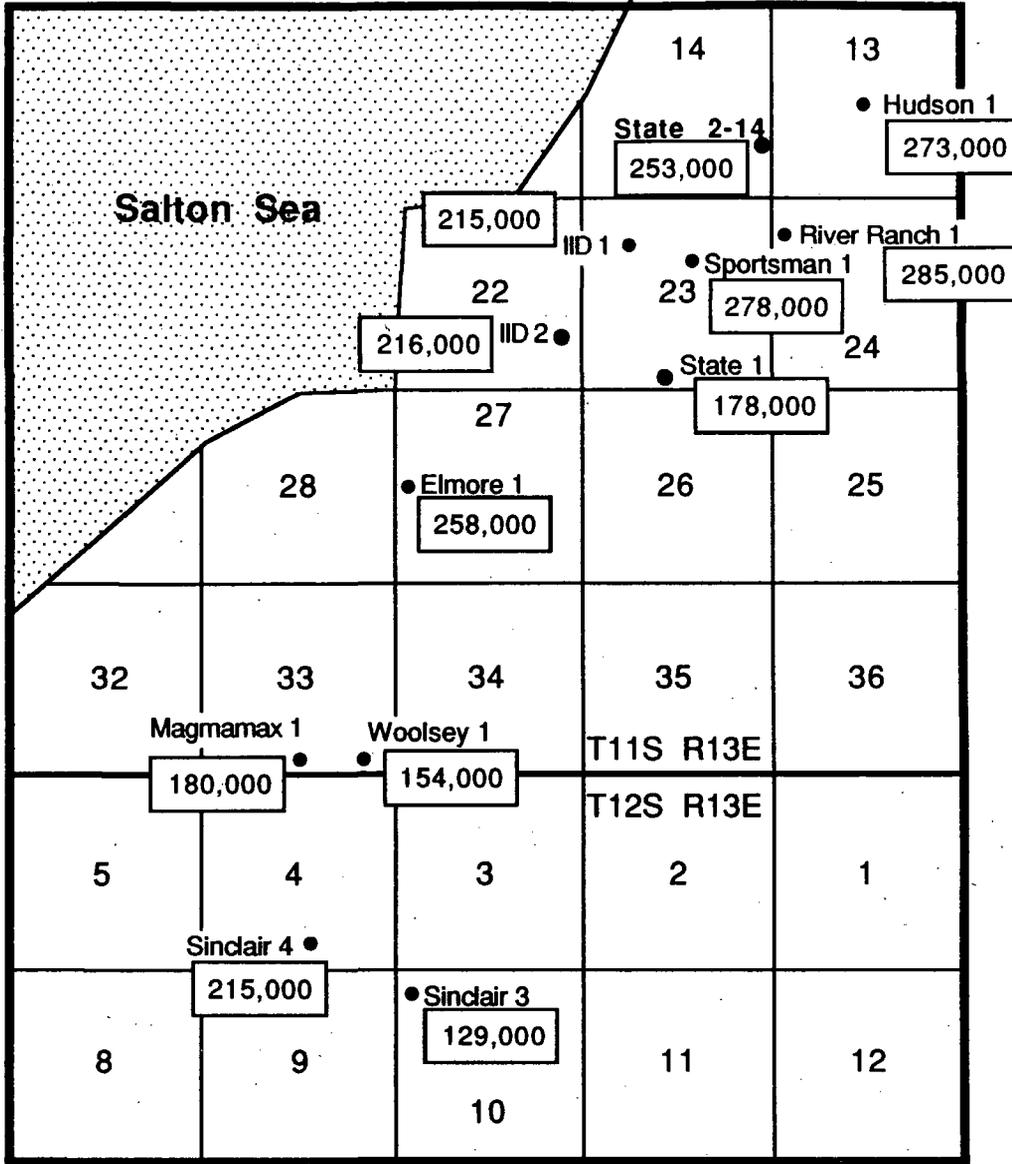


Figure 5-3 Well Locations Showing Total Dissolved Solids (mg/kg)

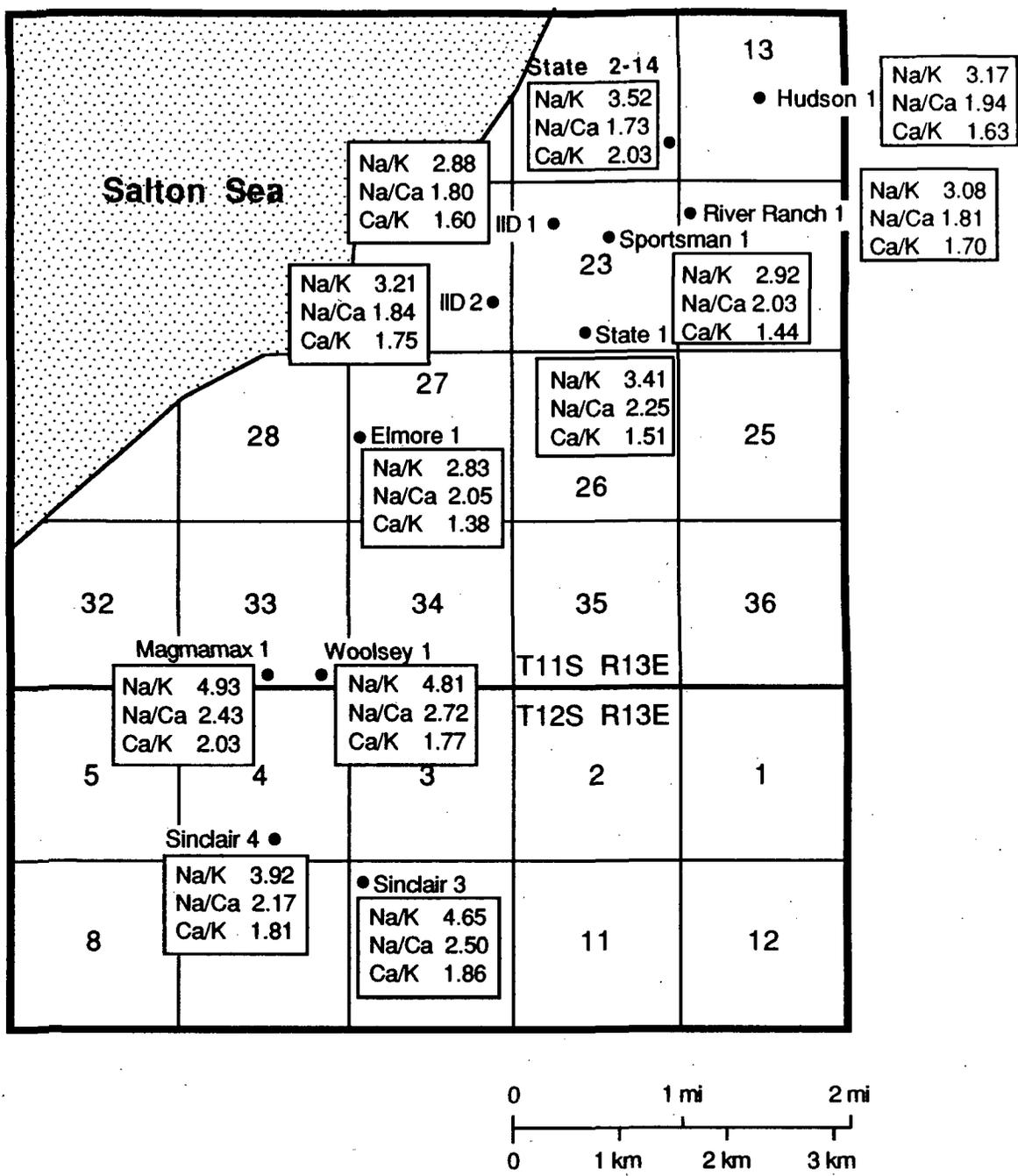


Figure 5-4 Well Locations Showing Geothermometers Na/K, Na/Ca and Ca/K

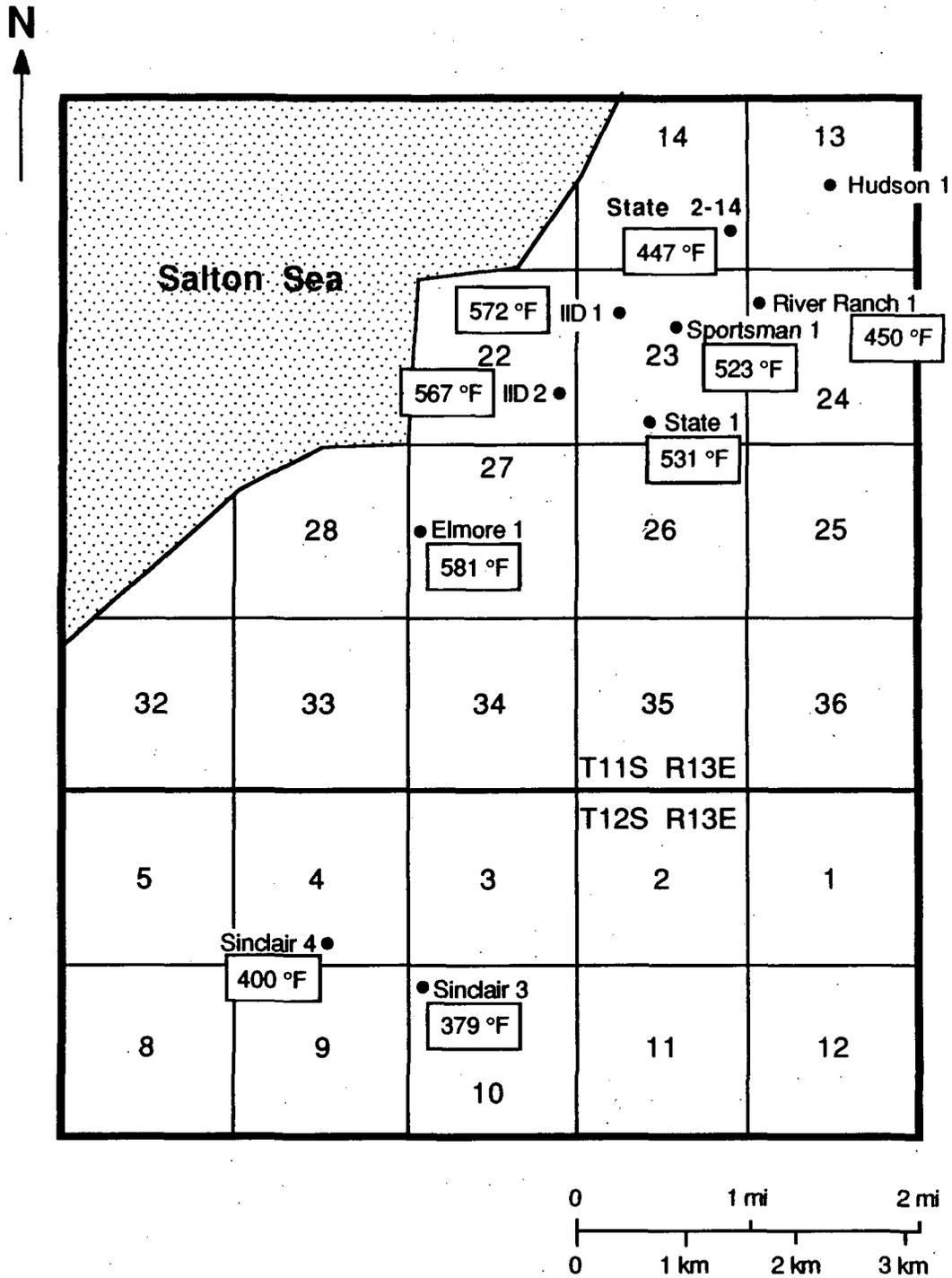


Figure 5-5 Well Locations Showing Static Temperatures at 3,000 ft (914 m) Depth

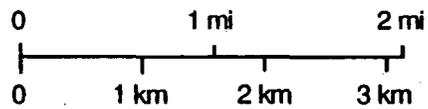
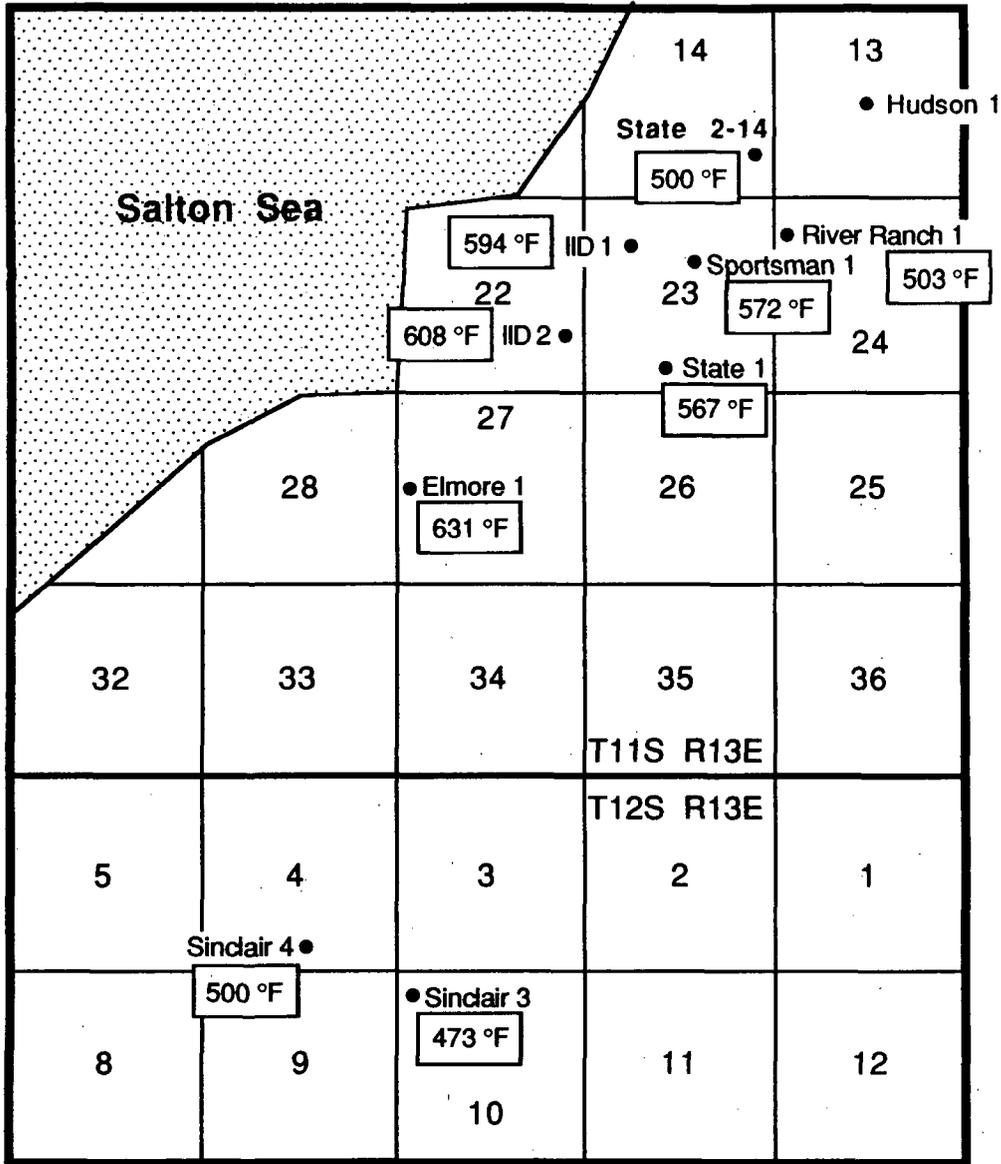


Figure 5-6 Well Locations Showing Static Temperatures at 4,000 ft (1,219 m) Depth

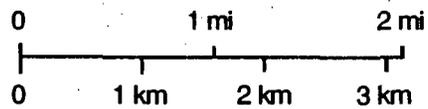
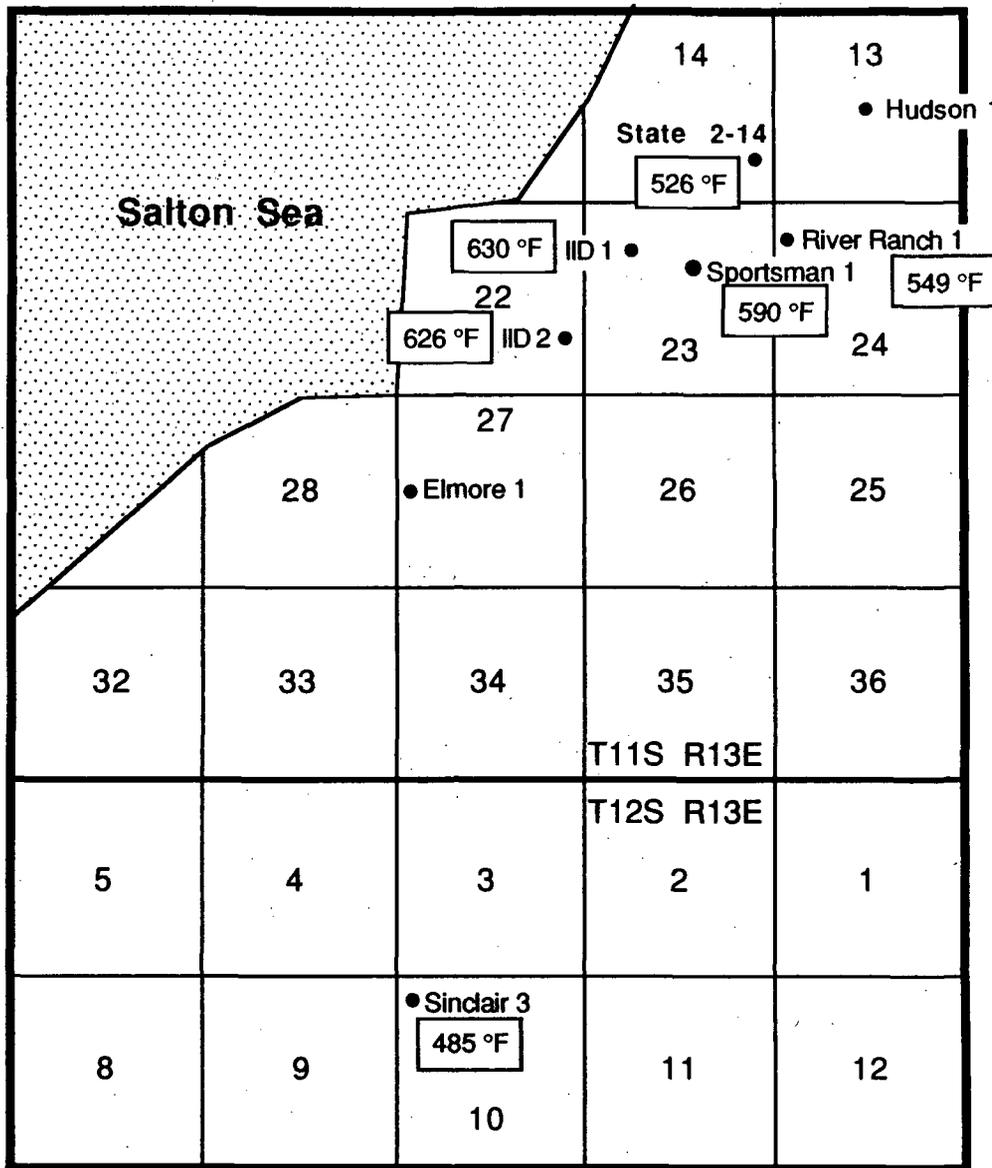


Figure 5-7 Well Locations Showing Static Temperatures at 5,000 ft (1,524 m) Depth

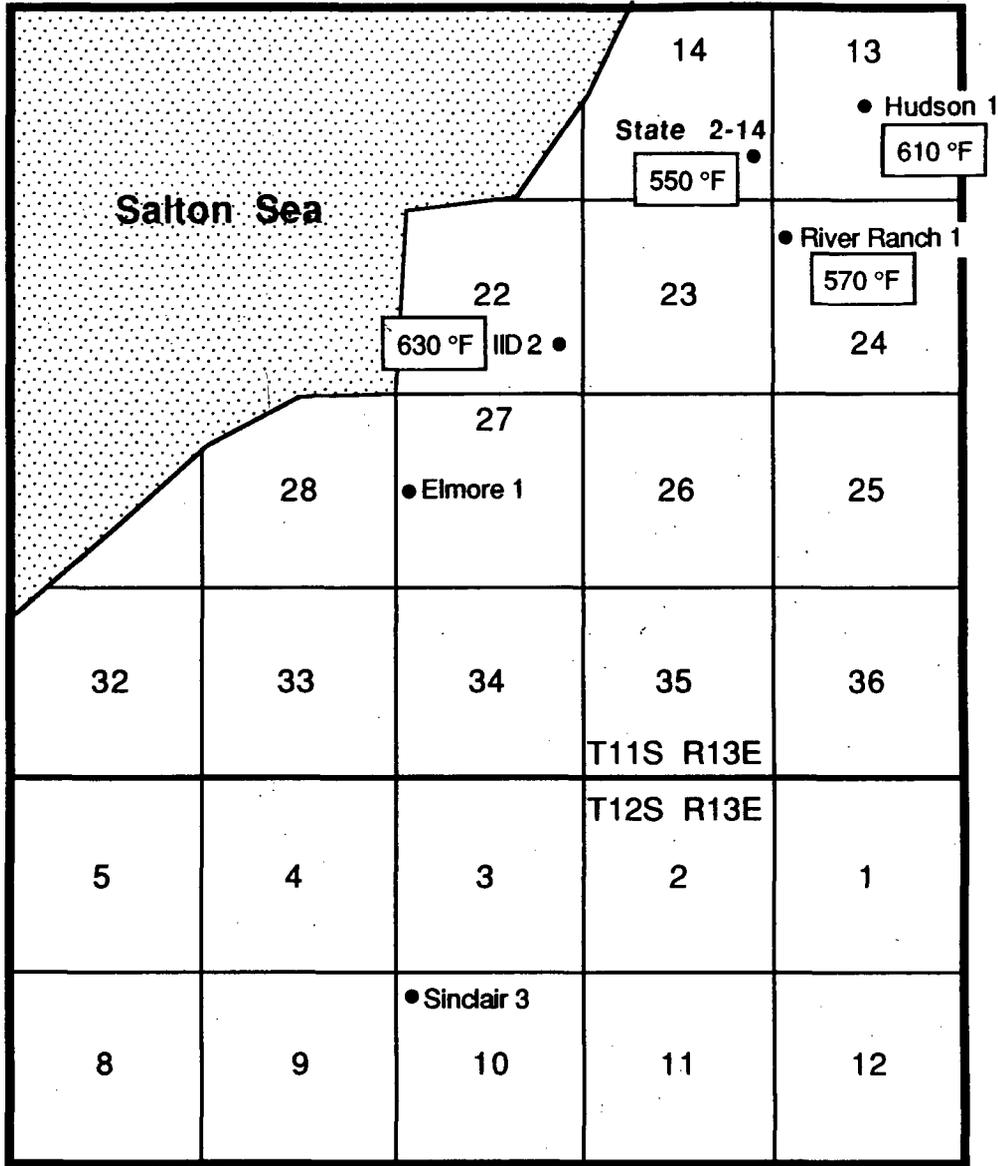


Figure 5-8 Well Locations Showing Static Temperatures at 6,000 ft (1,829 m) Depth

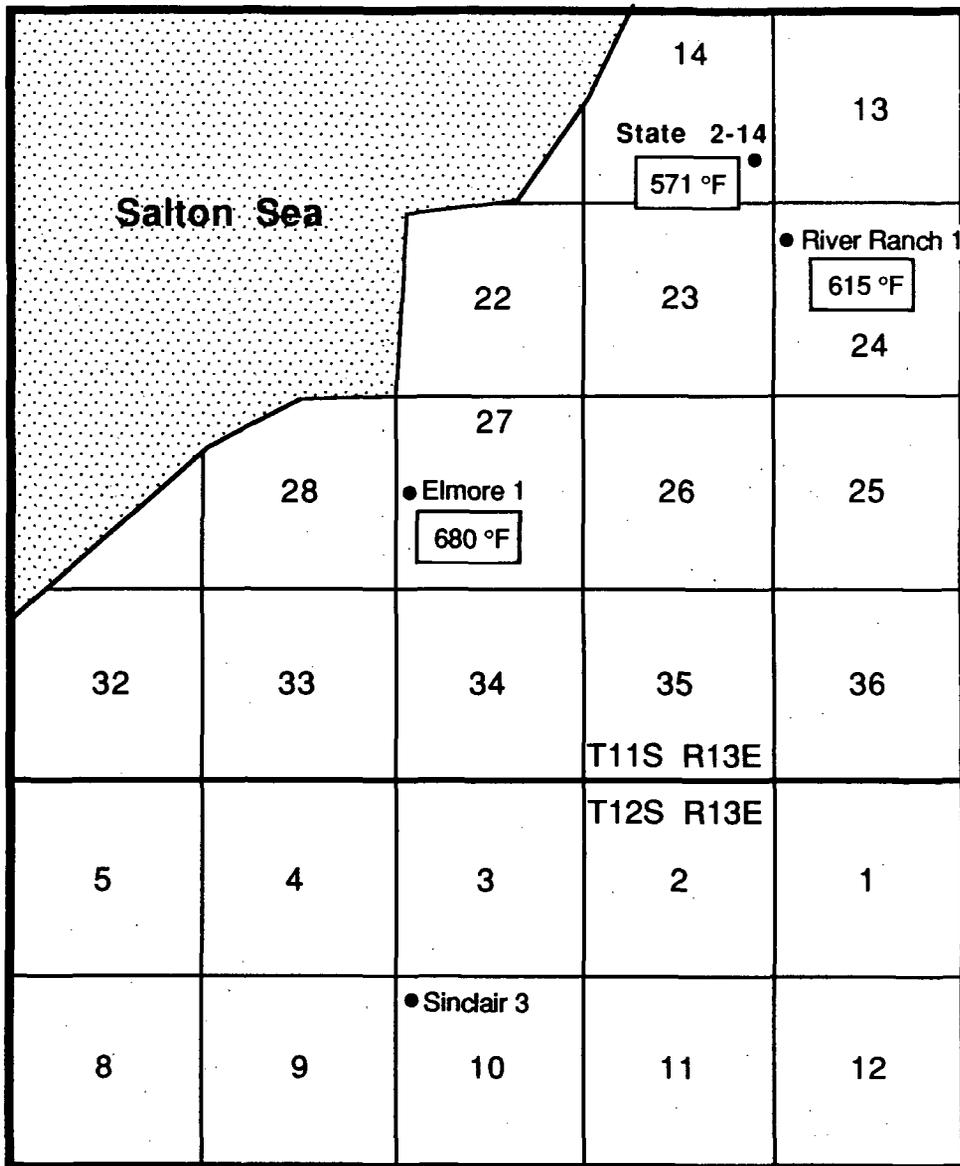


Figure 5-9 Well Locations Showing Static Temperatures at 7,000 ft (2,134 m) Depth

References

- Hardt, W. F., 1976, Selected Data on Water Wells, Geothermal Wells, and Oil Tests in the Imperial Valley California, U. S. Geological Survey, pp 11, 18-21, 37-40, 56-75.
- Michels, D. E., 1986, "SSSDP Fluid Compositions at First Flow Test of State 2-14," Geothermal Resources Council, TRANSACTIONS, Vol. 10, September, 1986, pp 461-465.
- Palmer, T. D., 1975, Characteristics of Geothermal Wells Located in the Salton Sea Geothermal Field, Imperial County, California, Lawrence Livermore Laboratory, Rept. UCRL-51976, pp 11-24, 28-36.
- Pimental, K. D., et al, 1978, Chemical Fingerprints to Assess the Effects of Geothermal Development on Water Quality in the Imperial Valley, Lawrence Livermore Laboratory, Rept. UCRL-81177, p 2.
- SDGE, 1977, Geothermal Loop Experimental Facility, SAN/1137-5, pp 19-20, Tables 3-4, 3-5, 3-8.

Addendum A

EPRI CHEMICAL ANALYSES DATA TABLES

Table 1
 SAMPLES AND CONDITIONS
 (RP2390-1, TOL-9, Salton Sea Deep Well, June 1988)

[261,30]GEOSUM.132;v4
 Status as of 8/1/88

Abb. ID	Date	Appr. Time	Description	Ice	Acid	Raw	Trap	Gas	FLOW CONDITIONS (1000-lb/hr)				
									PWH*	PSep*	Brine	Steam	
GRAB	6/1	am-pm	WEIR BOX			T							
GRAB	6/2	am-pm	WEIR BOX			T							
S-1S	6/7	1800	STEAM	O(1910)	A(1600)	A(1600)	A(1800)	A(1430)		212	112	26	
S-1B	6/7	1900	BRINE	O(2000)	A(1900)	A(1900)	A(2000)			212	112	26	
T-1	6/7	2000	BRINE		T	T							
T-2	6/8	1700	BRINE	A(1730)	T	T	A				104	24	
GRAB	6/8	1600	WEIR BOX		T	a							
GRAB	6/9	1400	POND SLUDGE			w							
T-3	6/9	2000	BRINE		T	T					216	54	
S-2B	6/10	0800	BRINE	O	A	A	A			200	195	52	
S-2S	6/10	1000	STEAM	O	A	A	A	A(2030)		200	195	52	
GRAB	6/10	1700	WEIR BOX			w							
GRAB	6/10	1930	INJECTION BRINE			w							
T-4	6/11	1200	BRINE	T	T	a					185	49	
T-5	6/12	2300	BRINE	T	T	a					351	99	
T-6	6/13	2000	BRINE	T	T	a					346	99	
S-3S	6/14	1700	STEAM	O(1800)	A(1700)	A(1730)	A(1800)			204	337	102	
S-3B	6/14	1700	BRINE	O(1630)	A(1700)	A(1700)	A(1730)			204	337	102	
T-7	6/15	1800	BRINE	T	T	a				247			
T-8	6/16	1200	BRINE	T	T	a					460	119	
T-9	6/17	1100	BRINE	T	T	a			430		556	145	
T-10	6/18	1000	BRINE	T	T	a							
T-11B	6/20	1700	BRINE	T	T	a	A				361	101	
T-11S	6/20	1700	STEAM		a		A(1600)	A(1730)			361	101	
GRAB	7/7	1300	POND WATER & SLUDGE			T							

KEY: T - Samples Taken
 A - Samples Analyzed
 O - Analysis Ordered
 a - Samples Analyzed for ph, Cond, EH, DO, & Cl Only
 w - Analyzed for weight per cent only

*PWH - Well Head Pressure (psig)
 *PSep - Pressure at the Separator (psig)

NOTE: BRINE and STEAM sampled after separator

Table 2

[261,30]GEOSUM.132;V4
Status as of 8/1/88ANALYSIS SUMMARY
(RP2390-1, TOL-9, Salton Sea Deep Well, June 1988)

Abb. ID	Date	Cl-	Na	K	Ca	Mg	Fe	Au	As	CO3=	S=	Na(AA)
GRAB	6/1	T	T	T	T	T	T	T	T			T
GRAB	6/2	T	T	T	T	T	T	T	T			T
S-1S	6/7	N	1.93	0.61	1.13	<0.01	<0.01	<0.01	.169	5890	447	1.32
S-1B	6/7	206,000	56,600	19,300	33,000	20.89	1850	18.3	8.31	N	7.0	71,100
T-1	6/7	199,000	45,900	18,000	35,600	20.8	1720	18.7	T			72,000
T-2	6/8	200,000	T	T	T	T	T	T	T	N	2.5	69,900
GRAB	6/8	214,000	T	T	T	T	T	T	T			67,700
GRAB	6/9	T	T	T	T	T	T	T	T			T
T-3	6/9	206,000	T	T	T	T	T	T	T			72,000
S-2B	6/10	210,000	78,800	18,500	42,400	19.3	1849	15.9	9.23	200	5.7	73,900
S-2S	6/10	N	14.3	5.35	8.94	0.0124	1.72	<.05	0.268	18,500	590.	11.6
GRAB	6/10	T	T	T	T	T	T	T	T			T
GRAB	6/10	T	T	T	T	T	T	T	T			T
T-4	6/11	208,000	T	T	T	T	T	T	T			77,000
T-5	6/12	212,000	T	T	T	T	T	T	T			77,700
T-6	6/13	212,000	T	T	T	T	T	T	T			82,000
S-3S	6/14	N	0.629	0.150	0.563	0.0175	0.268	<.05	0.151	21,020	N	0.36
S-3B	6/14	213,000	87,700	21,500	43,700	19.0	2060	17.0	16.4	370.	93.0	75,600
T-7	6/15	206,000	T	T	T	T	T	T	T			76,300
T-8	6/16	217,000	T	T	T	T	T	T	T			76,300
T-9	6/17	209,000	T	T	T	T	T	T	T			77,000
T-10	6/18	202,000	T	T	T	T	T	T	T			76,300
T-11B	6/20	211,000	T	T	T	T	T	T	T	360.	<0.4	81,300
T-11S	6/20	N	T	T	T	T	T	T	T	19,300	171.	0.85
GRAB	7/7	T	T	T	T	T	T	T	T			T

Notes: All values listed are in units of mg/l.
All metals analyzed by ICP unless otherwise specified.
Cl- analyzed by coulometric titration, CO3= & S= by trap methods

T - Sample Taken
O - Analysis Ordered
N - No Data from Sample

Table 3

[261,30]GEOSUM.132;V4
Status as of 8/1/88ANALYSIS SUMMARY
(RP2390-1, TOL-9, Salton Sea Deep Well, June 1988)

Abb. ID	Date	Cd	Pb	Ba	Sr	Ag	W	Co	Mn	Zn
GRAB	6/1	T	T	T	T	T	T	T	T	T
GRAB	6/2	T	T	T	T	T	T	T	T	T
S-1S	6/7	<0.01	0.0176	0.0443	0.0423	<0.01	<0.01	<0.01	0.240	<0.01
S-1B	6/7	0.66	111.	163.	483.	0.206	4.29	0.046	1680	601.
T-1	6/7	0.68	116.	146.	502.	0.218	4.40	0.045	1750	618.
T-2	6/8	T	T	T	T	T	T	T	T	T
GRAB	6/8	T	T	T	T	T	T	T	T	T
GRAB	6/9	T	T	T	T	T	T	T	T	T
T-3	6/9	T	T	T	T	T	T	T	T	T
S-2B	6/10	0.745	102.	101.	459.	0.234	4.51	0.039	1580	566.
S-2S	6/10	<0.01	0.026	0.101	0.169	<0.01	<0.10	<0.01	0.18	0.023
GRAB	6/10	T	T	T	T	T	T	T	T	T
GRAB	6/10	T	T	T	T	T	T	T	T	T
T-4	6/11	T	T	T	T	T	T	T	T	T
T-5	6/12	T	T	T	T	T	T	T	T	T
T-6	6/13	T	T	T	T	T	T	T	T	T
S-3S	6/14	<0.01	0.030	<0.01	<0.01	<0.01	<0.1	<0.01	0.019	<0.01
S-3B	6/14	0.63	100.	134.	527.	0.27	4.62	0.049	1610	653.
T-7	6/15	T	T	T	T	T	T	T	T	T
T-8	6/16	T	T	T	T	T	T	T	T	T
T-9	6/17	T	T	T	T	T	T	T	T	T
T-10	6/18	T	T	T	T	T	T	T	T	T
T-11B	6/20	T	T	T	T	T	T	T	T	T
T-11S	6/20	T	T	T	T	T	T	T	T	T
GRAB	7/7	T	T	T	T	T	T	T	T	T

Notes: All values listed are in units of mg/l.
All metals analyzed by ICP

T - Sample Taken
O - Analysis Ordered
N - No Data from Sample

Table 4

[261,30]GEOSUM.132;V4
Status as of 8/1/88ANALYSIS SUMMARY
(RP2390-1, TOL-9, Salton Sea Deep Well, June 1988)

Abb. ID	Date	S	Cr	V	Cu	Ti	Al	Ni	Mo	Sb	Sn	Li
GRAB	6/1	T	T	T	T	T	T	T	T	T	T	T
GRAB	6/2	T	T	T	T	T	T	T	T	T	T	T
S-1S	6/7	221.	<0.01	<0.01	<0.01	<0.01	0.13	<0.01	<0.01	<0.01	<0.01	<0.01
S-1B	6/7	232	0.115	0.38	2.29	<0.01	0.200	0.026	0.034	0.63	<0.01	224
T-1	6/7	223	0.118	0.38	1.82	<0.01	0.10	0.031	0.035	0.67	<0.01	234
T-2	6/8	T	T	T	T	T	T	T	T	T	T	T
GRAB	6/8	T	T	T	T	T	T	T	T	T	T	T
GRAB	6/9	T	T	T	T	T	T	T	T	T	T	T
T-3	6/9	T	T	T	T	T	T	T	T	T	T	T
S-2B	6/10	231.	0.027	0.476	3.71	<0.01	0.283	0.045	0.021	0.93	<0.06	231.
S-2S	6/10	90.0	0.013	<0.01	0.033	<0.01	0.030	<0.02	<0.02	<0.06	<0.06	0.120
GRAB	6/10	T	T	T	T	T	T	T	T	T	T	T
GRAB	6/10	T	T	T	T	T	T	T	T	T	T	T
T-4	6/11	T	T	T	T	T	T	T	T	T	T	T
T-5	6/12	T	T	T	T	T	T	T	T	T	T	T
T-6	6/13	T	T	T	T	T	T	T	T	T	T	T
S-3S	6/14	71.2	<0.01	<0.01	<0.01	<0.01	0.032	<0.02	<0.02	<0.06	<0.06	<0.05
S-3B	6/14	239.	0.29	0.499	5.24	<0.01	0.281	0.045	0.029	0.99	<0.06	247.
T-7	6/15	T	T	T	T	T	T	T	T	T	T	T
T-8	6/16	T	T	T	T	T	T	T	T	T	T	T
T-9	6/17	T	T	T	T	T	T	T	T	T	T	T
T-10	6/18	T	T	T	T	T	T	T	T	T	T	T
T-11B	6/20	T	T	T	T	T	T	T	T	T	T	T
T-11S	6/20	T	T	T	T	T	T	T	T	T	T	T
GRAB	7/7	T	T	T	T	T	T	T	T	T	T	T

Notes: All values listed are in units of mg/l.
All metals analyzed by ICP.

T - Sample Taken
O - Analysis Ordered
N - No Data from Sample

Table 5

[261,30]GEOSUM.132;V4
Status as of 8/1/88GC ANALYSIS SUMMARY
(RP2390-1, TOL-9, Salton Sea Deep Well, June 1988)

Abb. ID	Date	CO2	H2	H2S	N2	CH4	C2H6	C3H8	n-C4H10	i-C4H10	n-C5H12	i-C5H12
GRAB	6/1											
GRAB	6/2											
S-1S	6/7	36,600	19.9	141	56.1	82.7	38.5	48.0	36.7	103.	29.7	23.3
S-1B	6/7	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.
T-1	6/7											
T-2	6/8											
GRAB	6/8											
GRAB	6/9											
T-3	6/9											
S-2B	6/10	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.
S-2S	6/10	28,800	4.06	16.1	40.5	53.7	19.9	27.8	<14.5	68.6	<14.5	<14.5
GRAB	6/10											
GRAB	6/10											
T-4	6/11											
T-5	6/12											
T-6	6/13											
S-3S	6/14											
S-3B	6/14	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.
T-7	6/15											
T-8	6/16											
T-9	6/17											
T-10	6/18											
T-11B	6/20	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.
T-11S	6/20	28,700	5.51	40.0	110.	42.9	9.28	14.5	<14.5	39.7	<14.5	<14.5
GRAB	7/7											

Notes: All values listed are in units of (mg of non condensable gas)/(kg of steam after separator).
Results are from gas chromatography analysis of the non condensable gas fraction of the steam after the separator.
Less than numbers calculated from the estimated gas to brine ratio (less than 1 ml gas for 10 l of brine).

Table 6

[261,30]GEOSUM.132;V4
Status as of 8/1/88ANALYSIS SUMMARY
(RP2390-1, TOL-9, Salton Sea Deep Well, June 1988)

Abb. ID	Date	TDS mg/kg	Conduct. umho/cm	pH -log[H ⁺]	EH mV	Diss. O2 mg/kg	Turbidity NTU	Gas:Brine	B mg/l	TSS mg/kg
GRAB	6/1	T	T	T	T	T	T	N	T	T
GRAB	6/2	T	T	T	T	T	T	N	T	T
S-1S	6/7	T	2150.	5.87	-311.	<5	688	0.0372	17.2	T
S-1B	6/7	T	535,000	4.89	-58.	<5	563	N	570.	T
T-1	6/7	T	535,000	4.89	-58.	<5	T	N	576.	T
T-2	6/8	T	535,000	5.47	-118.	<5	T	N	T	T
GRAB	6/8	T	653,000	4.57	10	20	T	N	T	T
GRAB	6/9	T	T	T	T	T	T	N	T	T
T-3	6/9	T	629,000	4.74	-49	20	T	N	T	T
S-2B	6/10	331,000	T	5.31	T	T	147.	N	T	7,490
S-2S	6/10	21.	T	6.15	T	T	60.	0.029	T	<10.
GRAB	6/10	T	T	T	T	T	T	N	T	T
GRAB	6/10	T	T	T	T	T	T	N	T	T
T-4	6/11	T	628,000	5.04	29	5	T	N	T	T
T-5	6/12	T	685,000	5.16	-40	23	T	N	T	T
T-6	6/13	T	645,000	5.14	-50	20	T	N	T	T
S-3S	6/14	15.8	2560.	6.38	-292	0.3	81.	N	T	T
S-3B	6/14	332,000	648,000	5.34	-38	7.2	76.	N	T	9130
T-7	6/15	T	627,000	5.48	-48	7	T	N	T	T
T-8	6/16	T	640,000	5.49	-72	7	T	N	T	T
T-9	6/17	T	648,000	5.46	-95	5	T	N	T	T
T-10	6/18	T	632,000	5.47	-71	7	T	N	T	T
T-11B	6/20	T	636,000	5.48	-81	10	T	N	T	T
T-11S	6/20									
GRAB	7/7	T	T	T	T	T	T	N	T	T

Notes: B analyzed by ICP

T - Sample Taken
O - Analysis Ordered
N - No Data from Sample

Table 7

[261,30]GEOSUM.132;V4
Status as of 8/1/88ANALYSIS SUMMARY
(RP2390-1, TOL-9, Salton Sea Deep Well, June 1988)

Abb. ID	Date	F-	Cl-	NO3-	SO4=	Br-	I-	NH4+	As	Hg	Se
GRAB	6/1	T	T	T	T	T	T	T	T	T	T
GRAB	6/2	T	T	T	T	T	T	T	T	T	T
S-1S	6/7	<0.05	7.30	0	6.99	0	0	403	0.16	<0.002	<0.001
S-1B	6/7	235.	205,000	0	110.	0	0	478	8.23	<0.002	<0.001
T-1	6/7	232	204,000	0	<50	0	0	T	T	T	T
T-2	6/8	234	204,000	0	<50	0	0	T	T	T	T
GRAB	6/8	T	T	T	T	T	T	T	T	T	T
GRAB	6/9	T	T	T	T	T	T	T	T	T	T
T-3	6/9	T	T	T	T	T	T	T	T	T	T
S-2B	6/10	0	0	0	0	0	0	0	9.13	<0.002	<0.001
S-2S	6/10	0	0	0	0	0	0	0	0.27	<0.002	<0.001
GRAB	6/10	T	T	T	T	T	T	T	T	T	T
GRAB	6/10	T	T	T	T	T	T	T	T	T	T
T-4	6/11	T	T	T	T	T	T	T	T	T	T
T-5	6/12	T	T	T	T	T	T	T	T	T	T
T-6	6/13	T	T	T	T	T	T	T	T	T	T
S-3S	6/14	0	0	0	0	0	0	0	16.2	<0.002	<0.001
S-3B	6/14	0	0	0	0	0	0	0	0.185	<0.002	0.0012
T-7	6/15	T	T	T	T	T	T	T	T	T	T
T-8	6/16	T	T	T	T	T	T	T	T	T	T
T-9	6/17	T	T	T	T	T	T	T	T	T	T
T-10	6/18	T	T	T	T	T	T	T	T	T	T
T-11B	6/20	T	T	T	T	T	T	T	T	T	T
T-11S	6/20	T	T	T	T	T	T	T	T	T	T
GRAB	7/7	T	T	T	T	T	T	T	T	T	T

Notes: Anions analyzed by Ion Chromatography, Ammonia analyzed by Spectrophotometry. T - Sample Taken
 As and Se analyzed by AA hydride, Hg analyzed by cold vapor AA. O - Analysis Ordered
 Barely detectable amounts of Hg were noted on signature brines during analysis. N - No Data from Sample

Addendum B

**CHEMICAL SAMPLING AND ANALYSIS BY THE EPRI
MOBILE GEOTHERMAL LABORATORY**

CHEMICAL SAMPLING AND ANALYSIS BY THE
EPRI MOBILE GEOTHERMAL LABORATORY

The Electric Power Research Institute's Mobile Geothermal Chemistry Laboratory (EPRI CHEMLAB) visited the Salton Sea site during the June 1988 flow test to collect and analyze samples from the well (State Well 2-14).

Three types of sampling events took place during the flow test. These types are defined in terms of their objectives as follows:

<u>TEST TYPE</u>	<u>OBJECTIVE</u>
• Signature	- To characterize chemical and physical attributes of the total flow from the well. This involves combining measurements of steam and brine to determine properties of the total flow.
• Tracking	- To observe changes in selected parameters as a function of time.
• Special	- To investigate flow streams or equipment of special interest.

The sampling schedule appears in Table 1, which shows the test location, sampling date, flow rates, and test type. The CHEMLAB remained on site throughout the flow test. CHEMLAB staff worked alongside other investigators some of whom also collected samples for chemical analyses.

Signature Tests

Complete Signature Tests were conducted at three well flow rates. The Signature Tests included the measurement of 64 separate chemical species. Standard methods of sampling and analysis (developed by CHEMLAB staff) included the collection of condensate samples with the use of a two-stage condenser made from coiled 3/8" stainless steel tubing. The stages consisted of a boiling water bath followed by an ice water bath.

Raw condensate samples were collected in order to measure pH, conductivity, Eh, dissolved oxygen, anions, carbonate and bicarbonate. Acidified samples (1% nitric acid) were taken for the analysis of about 30 different metals. Trapping solutions were utilized to trap and measure hydrogen sulfide and carbon dioxide. CHEMLAB's Fluid Sampling System (FSS) was used to obtain the noncondensable gases (at approximately atmospheric pressure and 25°C temperature) for analysis by gas chromatography.

The flow of the mixed fluid through the separator began on June 7 at approximately 0500 hours. Signature sampling began at approximately 1600 hours the same day. The CHEMLAB staff conducted Signature Tests on the separated steam and brine using the Lawrence Livermore Laboratory sampling probe provided by Dave Mulliner of Kennecott.

Selected results for the steam and brine flow streams sampled during the three Signature Tests are given in Table 2.

Tracking Tests

Daily Tracking Tests were conducted at the brine port from June 7 to June 20 (except for June 19). This port sampled the separated brine emerging from the separator as in the Signature Test. An additional Tracking Test was conducted at the weir box in order to allow for the comparison of data generated by others who sampled at the weir box rather than at the brine port. One tracking test was conducted at the steam port on the last day of the test.

Raw samples were collected during Tracking Tests for immediate measurement of pH, conductivity, Eh, dissolved oxygen, and chloride (by coulometric titration). Acidified samples were taken for analysis of approximately 30 metals at C-E Environmental's analytical facility (EMSI) in Camarillo, California, by inductively coupled argon plasma spectrophotometry (ICAP).

Special Tests

The Special Tests conducted included the collection of raw samples for a determination of the total suspended solids (TSS). These results were made available during the test to the Bechtel project management in an effort to help with estimating the sludge accumulation rate in the brine pond.

Sampling locations for the Special Tests were at the weir box, injection pump, and brine pond for sludge and liquid. There were three events at the weir box, two of which were samples taken by Dave Mulliner of Kennecott on June 1 and June 2. There were two sampling events at the brine pond (the first for sludge and the second for both sludge and the pond liquid). There was one event at the injection pump, and this sample was taken by the Mesquite Group, Inc.

Weight percent determinations were made on samples coming into and leaving the brine pond. The difference in the TSS measurement between these two samples provided the quantitative information necessary to estimate the sludge accumulation rate.

Status

The analysis of signature samples was nearly complete at the time this report was prepared. Dave Mulliner of Kennecott had reported good agreement where comparison was possible. The ion balance of the analytic data had also been checked and the results were satisfactory.

Tracking samples were still being analyzed for chloride and nitrate (by ion chromatography) and for all 30 metals (by ICAP). Results were not yet available when this report was prepared. The immediate results from the daily tracking measurements (pH, Eh, conductivity, dissolved oxygen, and chloride) agreed well with each other and with the Signature Test results.

Table 1

FIELD ACTIVITIES, SALTON SEA DEEP WELL, IMPERIAL VALLEY, CALIFORNIA

Test Location ¹	Sampling Dates	Approx. Time	Flows (1000 lb/h) ³		Test Type	Rep #
			Brine	Steam		
WEIR BOX ²	6/1	1900	120.	not separated	SPECIAL	1
WEIR BOX ²	6/2	0100	161.	" "	SPECIAL	2
STEAM	6/7	1800	111.	20.2	SIGNATURE	1
BRINE	6/7	1900	111.	20.2	SIGNATURE	1
BRINE	6/7	2000	103.	20,2	TRACKING	1
BRINE	6/8	1700	90.5	18.9	TRACKING	2
WEIR BOX	6/8	1600	90.5	18.9	SPECIAL	3
POND SLUDGE ⁴	6/9	1400	222.	37.0	SPECIAL	4
BRINE	6/9	2000	197.	33.3	TRACKING	3
BRINE	6/10	1000	193.	30.3	SIGNATURE	2
STEAM	6/10	0800	193.	33.3	SIGNATURE	2
WEIR BOX ⁴	6/10	1700	181.	29.3	SPECIAL	5
INJECTION BRINE ⁴	6/10	1930	214.	30.1	SPECIAL	6
BRINE	6/11	1200	185.	29.1	TRACKING	4
BRINE	6/12	2300	349.	59.6	TRACKING	5
BRINE	6/13	2000	344.	60.0	TRACKING	6
STEAM	6/14	1700	344.	62.9	SIGNATURE	3
BRINE	6/14	1700	344.	62.0	SIGNATURE	3
BRINE	6/15	1800	453.	78.7	TRACKING	7
BRINE	6/16	1200	421.	74.9	TRACKING	8
BRINE	6/17	1100	562.	91.0	TRACKING	9
BRINE	6/18	1000	194.	26.1	TRACKING	10
BRINE	6/20	1700	374.	60.7	TRACKING	11
STEAM	6/20	1700	374.	60.7	TRACKING	11
POND WATER/SLUDGE	7/7	1300	0	0	SPECIAL	7

1 "STEAM" and "BRINE" are at sampling ports on the lines leaving the separator.

2 Samples taken by Dave Mulliner of Kennecott. Two additional samples were taken several hours apart later that same day.

3 Flows as reported by the Mesquite Group, Inc.

4 Samples taken by the Mesquite Group, Inc.

Table 2

ANALYSIS SUMMARY
(RP-2390, TOL-9, Salton Sea Deep Well, June 1988)

ANALYTE	STEAM SIGNATURE (mg/l)			BRINE SIGNATURE (mg/l)		
	SIG 1	SIG 2	SIG 3	SIG 1	SIG 2	SIG 3
Chloride	7.3	-	-	206,000	210,000	213,000
Sodium*	1.93	14.3	0.63	71,100	73,900	75,600
Potassium	0.61	5.35	0.15	19,300	18,500	21,500
Calcium	1.13	8.94	0.56	33,000	42,400	43,700
Magnesium	<0.01	0.012	0.017	20.9	19.3	19.0
Iron	<0.01	1.72	0.27	1,850	1,850	2,060
Silicon	0.37	3.84	1.25	-	178	167
Lead	0.012	0.026	0.03	111	102	100
Cadmium	<0.01	<0.01	<0.01	0.66	0.75	0.63
Tungsten	<0.1	<0.1	<0.1	4.29	4.51	4.62
Silver	<0.01	<0.01	<0.01	0.206	0.234	0.270
Arsenic	0.16	0.27	0.19	8.23	9.13	16.2
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.0012
CO ₂ **	-	13,600	15,400	-	147	270
H ₂ S**	475	627	-	7.4	6.1	-

* Sodium analyzed by flame Atomic Absorption Spectrophotometry. All other metal analyses performed by ICAP spectrophotometry.

** Measurements for carbonate and sulfide were made using trapping solutions to sample. The results were normalized to carbon dioxide and hydrogen sulfide respectively.

Addendum C

CHEMICAL ANALYSIS TABLE FOR MARCH 1986 TEST



QUALITY ASSURANCE LABORATORY

Kennecott
ATT: Larry Grogan
1097 Airport Road
P.O. Box 278
Imperial, CA 92251

April 16, 1986

Date Sample Received: March 25, 1986
Date of Sample: March 21, 1986
Date Analyses Completed: April 14, 1986
Analyzed By: NC RG RT
Sample No. & Type: 1 Liquid

ANALYSES - RESULTS

Analyses	#3 1937-86
Boron mg/l	428
Chloride mg/l	182,480.2
Fluoride mg/l	5.7
Ammonia mg/l	411.2
Sulfate mg/l	8.200
T.S. mg/l	<2.2
Aluminum mg/kg	7.3
Antimony mg/kg	<1.0
Arsenic mg/kg	70.1
Barium mg/kg	368.4
Cadmium mg/kg	1.8
Calcium mg/kg	35,300
Chromium mg/kg	<0.2
Copper mg/kg	4.0
Cesium mg/kg	102.5
Lithium mg/kg	260

Mailing Address:
P.O. Box 22567
San Diego, CA 92122



6555 Nancy Ridge Dr.
Suite #300
San Diego, CA 92121
(619) 566-1060

QUALITY ASSURANCE LABORATORY

Page 2
Kennecott

Iron mg/kg	1,457
Lead mg/kg	83.3
Magnesium mg/kg	48.0
Manganese mg/kg	1,425
Mercury mg/kg	<0.01
Nickel mg/kg	3.5
Potassium mg/kg	16,016
Silicon mg/kg	307.5
Sodium mg/kg	65,500
Strontium mg/kg	384.4
Tin mg/kg	11.2
Zinc mg/kg	38.1
Rubidium mg/kg	113.7
Bromine mg/l	1,690
Iodine mg/l	<5
Selenium mg/l	<0.1

Peter T.L. Shen
Peter T.L. Shen
Laboratory Director