

STATUS REPORTDATA COMPILATION OF CHEMICAL ANALYSISOF THE RAFT RIVER GEOTHERMAL MONITOR, CULINARY, AND IRRIGATION WELLSI. INTRODUCTION

This report briefly evaluates the data from the chemical analysis of the geothermal, monitor, culinary, and irrigation wells located in the area of the Raft River geothermal site. The data includes the following:

- (1) The routine analysis performed at the Raft River laboratory.
- (2) An interlaboratory comparison of the chemical analysis of the geothermal and monitor wells. The participating laboratories were the Raft River laboratory, the Energy Incorporated (EI) laboratory in Idaho Falls, and the Analytical Chemistry laboratory with the Idaho National Engineering Laboratory (INEL).
- (3) The chloride and conductivity data from the salt monitoring program.
- (4) The data from the analyses performed at the analytical chemistry laboratory at the INEL prior to January 1977.

The purpose of this report is to describe the data and to explain its purpose. Also, it presents the opportunity to compile this information to make recall easier.

II. RAFT RIVER LABORATORY'S ROUTINE ANALYSIS DATA

Table I lists the average values for the chemical species routinely analyzed at the Raft River Laboratory. The last two columns show the date the routine analysis began and the date of the last analysis used for the table. Average values for the concentration of the chemical species listed have limitations in describing the chemical histories of the wells and the Raft River. First trends in chemical change cannot be noted. Also, in the case of the Raft River seasonal changes take place. However, the graphic plot of chemical

concentration versus time for the chemical species analyzed for Table I is a major task and was not considered for this report. Variables in the integrity of the data in Table I result from having several chemical technicians performing the analysis and instrumental changes over the period of time that the routine analysis were performed.

III. INTERLABORATORY COMPARISONS OF THE CHEMICAL ANALYSIS OF THE WATER FROM THE RAFT RIVER GEOTHERMAL WELLS PERFORMED BY THE RAFT RIVER, EI, AND THE INEL ANALYTICAL CHEMISTRY LABORATORIES

Table II is a list of the concentrations for the chemical species analyzed in an interlaboratory study. Water samples were collected from all of the geothermal wells capable of flowing at that time. Similar water samples were submitted to the chemical laboratories at Raft River, EI, and INEL. Comparison of the results indicated poor precision between laboratories on F^- , SiO_2 , and Cl^- concentrations. Other species compared well between two of the laboratories but not the third. In general, there was poor precision between the laboratories. Further evaluation of data and procedures are needed to ascertain where the problem is located.

IV. INTERLABORATORY COMPARISONS OF CHEMICAL ANALYSIS OF THE WATER FROM THE RAFT RIVER MONITOR WELLS PERFORMED BY THE RAFT RIVER, EI, AND INEL LABORATORIES

Table III is the list of concentrations for the chemical species analyzed in an interlaboratory study. Similar water samples were collected from the seven Raft River monitor wells and submitted to the Raft River, EI, and INEL analytical chemistry laboratories for analysis. Data comparison between laboratories shows similar trends in precision as those observed in the interlaboratory study of the geothermal wells. Both data sets will be important in ascertaining the problem.

V. DATA FROM THE SALT MONITORING PROGRAM

Table IV is a listing of the chemical analysis on water from the wells selected for the salt monitoring program. The chloride and conductivity data are averages of all the data collected up to the time when the irrigation wells were shut-in for the season. Table V is the same chloride and conductivity data except it includes the standard deviation for a single value. This can be used to show the average concentrations for the chloride and conductivity with the concentration span for each chemical species.

VI. CHEMICAL ANALYSES PERFORMED BY THE INEL ANALYTICAL CHEMISTRY LABORATORY PRIOR TO JANUARY 1977

Table VI is the average values and standard deviation of a single value for chemical analysis performed by the INEL analytical chemistry laboratory prior to January 1977. The purpose of including this data in the report is to furnish as much data as possible covering the time period between the completion of geothermal well RRGE-1 and the present.

VII. CONCLUSIONS

This report is primarily a description of much of the chemical analysis performed on the water from the wells in the area of the Raft River geothermal site. It was placed in the report so that the report could serve as a reference for chemical data on the described wells. However, the interlaboratory studies disclose serious discrepancies in data precision between the laboratories. Further study of the data is necessary to determine the problem areas. This may result from instrumentation, standardization procedures or analytical technique. It is one of the more serious problems to be solved in a quality assurance program.

TABLE I

DATA FROM ROUTINE ANALYSIS OF WELLS AT THE RAFT RIVER GEOTHERMAL SITE

WELL NAME	CONDUCTIVITY	pH	F ⁻	CL ⁻	HARDNESS	ALKALINITY	SiO ₂	DATE FIRST	DATE FINAL
RRGE-1	2915	8.1	7.9	765	124	36.8	133	5-15-77	10-2-78
RRGE-2	1864	7.5	8.7	494	80	46.4	-	10-16-77	6-5-78
RRGE-3	6995	7.6	6.8	2198	619	32.2	-	7-6-77	6-26-78
RRGI-4	6450	7.7	6.8	2250	474	-	-	10-16-77	4-24-78
RRGP-5	2150	7.3	8.7	900	100	143.4	-	BEFORE SALT WAS USED	
RRGI-6	10567	7.3	8.2	3338	407	60.3	-	5-30-78	6-12-78
MW-1	10937	7.7	5.1	3591	496	22.4	-	4-24-78	10-2-78
MW-3	5924	7.4	5.5	1780	756	53.6	-	1-11-77	10-2-78
CROOK HOT WELL	5430	7.9	7.1	1790	318	28.9	-	6-26-77	10-2-78
BLM	2996	7.5	7.9	848	140	38.1	-	5-29-77	10-2-78
DOMESTIC #1	1997	7.7	5.7	529	154	88.9	-	5-29-77	10-2-78
RAFT RIVER	1189	7.9	0.88	233	297	140	-	4-24-77	10-2-78

NOTE: CONCENTRATIONS ARE IN $\mu\text{g}/\text{mL}$ EXCEPT FOR CONDUCTIVITY WHICH IS IN μS

TABLE II
ROUND ROBIN ANALYSIS

ANALYSIS PERFORMED AT THE INEL LABORATORY

WELL NAME	pH	CONDUCTIVITY	CL ⁻	F ⁻	ALKALINITY	SiO ₂	TDS	SO ₄ ⁼	Mg	Na	Li	Sr	Ca	K
RRGE-1	7.3	2987	709	5.7	34	134	1607	40	0.59	469	1.6	1.4	53	33
RRGE-2	7.6	2157	701	7.9	42	155	1161	29	0.67	331	1.0	0.8	32	31
RRGE-3	7.2	7997	2116	3.7	26	158	4280	44	1.02	1245	3.4	5.2	127	103
RRGP-5B	7.5	2857	590	6.2	40	136	1482	40	0.54	179	1.6	1.2	50	34
RRGI-6	7.3	11594	3636	5.8	62	91	6330	60	1.37	2020	5.1	8.0	199	32

ANALYSIS PERFORMED BY ENERGY INC. LABORATORY

WELL NAME	pH	CONDUCTIVITY	CL ⁻	F ⁻	ALKALINITY	SiO ₂	TDS	SO ₄ ⁼	Mg	Na	Li	Sr	Ca	K
RRGE-1	7.5	1846	1016	3.0	34	148	1634	64	-	-	-	-	60	-
RRGE-2	8.0	1500	747	3.8	42	150	1196	38	-	-	-	-	33	-
RRGE-3	7.5	4950	2634	2.0	26	182	4366	59	-	-	-	-	221	-
RRGP-5B	8.0	2910	1089	3.2	40	140	1618	56	-	-	-	-	52	-
RRGI-6	7.8	8150	3619	2.8	66	96	6286	61	-	-	-	-	163	-

ANALYSIS PERFORMED AT THE RAFT RIVER LABORATORY

WELL NAME	pH	CONDUCTIVITY	CL ⁻	F ⁻	ALKALINITY	SiO ₂	TDS	SO ₄ ⁼	Mg	Na	Li	Sr	Ca	K
RRGE-1	7.5	2800	913	7.6	37	148	-	-	-	-	-	-	55	-
RRGE-2	7.7	2000	610	10.4	45	163	-	-	-	-	-	-	33	-
RRGE-3	7.4	7250	2740	5.0	26	186	-	-	-	-	-	-	233	-
RRGP-5B	7.8	2600	838	8.2	44	162	-	-	-	-	-	-	55	-
RRGI-6	7.5	10500	3915	7.3	63	110	-	-	-	-	-	-	170	-

NOTE: CONCENTRATIONS ARE IN µg/mL EXCEPT CONDUCTIVITY WHICH IS IN µS

TABLE III

ROUND ROBIN ANALYSIS OF THE MONITOR WELLS

ANALYSIS PERFORMED AT THE INEL LABORATORY

WELL NAME	pH	CONDUCTIVITY	CL ⁻	F ⁻	ALKALINITY	TSS	TDS	SO ₄ ⁼	Mg	Na	Li	Sr	Ca	K	NO ₃ ⁻	Fe	NH ₄ ⁺	Mn	SiO ₂
MW-1	7.8	11350	3670	2.8	25	-	6590	67	0.47	2270	4.1	7.0	210	28	< 5	-	-	-	79
MW-2	7.6	5700	1700	5.7	26	-	3130	68	0.70	1320	2.6	3.8	140	24	< 5	-	-	-	84
MW-3	7.5	7700	2400	5.6	46	-	4920	48	3.4	1350	3.1	1.8	170	54	< 5	-	-	-	92
MW-4	7.7	7800	2610	5.6	30	-	4510	48	0.50	1450	3.3	0.8	160	23	< 5	-	-	-	82
MW-5	7.8	2000	560	>0.1	114	-	1180	20	21	485	0.4	0.8	110	12	< 5	-	-	-	34
MW-6	10.6	7600	2340	4.1	99	-	4270	63	>0.1	1170	2.8	1.4	170	62	< 5	-	-	-	30
MW-7	7.8	2300	650	1.0	102	-	1300	25	17	375	0.6	0.8	94	14	< 5	-	-	0.29	43

ANALYSIS PERFORMED AT THE ENERGY INC. LABORATORY

WELL NAME	pH	CONDUCTIVITY	CL ⁻	F ⁻	ALKALINITY	TSS	TDS	SO ₄ ⁼	Mg	Na	Li	Sr	Ca	K	NO ₃ ⁻	Fe	NH ₄ ⁺	Mn	SiO ₂
MW-1	7.9	7750	3680	3.4	25	14	6270	66	0.35	2220	3.7	-	215	30	0.08	0.6	1.8	-	80
MW-2	7.6	4400	1740	5.4	26	21	3190	57	0.49	1000	2.5	-	125	25	<0.01	0.5	0.1	-	87
MW-3	7.8	5500	2420	5.1	55	376	4350	52	4.6	1280	2.8	-	177	54	0.09	7.7	0.6	-	101
MW-4	8.1	5750	2420	4.9	41	628	4370	51	3.2	1400	3.2	-	217	25	0.09	12.8	1.7	-	67
MW-5	8.0	2000	610	0.5	168	2906	1240	40	33.9	190	1.7	-	169	17	0.44	5.7	< 0.05	-	37
MW-6	10.7	5600	2360	3.4	87	145	4240	62	0.1	1280	2.4	-	180	53	0.02	0.3	< 0.05	-	33
MW-7	8.0	2250	640	1.0	107	209	1380	32	28.9	350	1.6	-	110	12	2.92	7.6	0.1	-	36

ANALYSIS PERFORMED AT THE RAFT RIVER LABORATORY

WELL NAME	pH	CONDUCTIVITY	CL ⁻	F ⁻	ALKALINITY	TSS	TDS	SO ₄ ⁼	Mg	Na	Li	Sr	Ca	K	NO ₃ ⁻	Fe	NH ₄ ⁺	Mn	SiO ₂
MW-1	8.1	10400	4130	3.4	28	-	-	-	-	1970	-	-	223	-	-	-	-	-	-
MW-2	7.6	5400	2000	6.1	28	-	-	-	-	920	-	-	138	-	-	-	-	-	-
MW-3	7.5	5200	2730	5.7	44	-	-	-	-	1250	-	-	182	-	-	-	-	-	-
MW-4	8.0	7400	2850	5.9	29	-	-	-	-	1350	-	-	157	-	-	-	-	-	-
MW-5	7.6	1990	639	0.7	102	-	-	-	-	221	-	-	132	-	-	-	-	-	-
MW-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-7	7.6	2200	707	1.3	-	-	-	-	-	287	-	-	129	-	-	-	-	-	-

TABLE IV

ROUTINE AND CHLORIDE MONITORING DATA OF WELLS AT THE RAFT RIVER GEOTHERMAL SITE

(DATA FOR CHLORIDE AND CONDUCTIVITY ARE AN AVERAGE OF AVAILABLE DATA, OTHER DATA IS FROM DATA SHEET 7-26-78)

WELL NAME	LOCATION	CONDUCTIVITY	pH	Cl ⁻	F ⁻	HARDNESS	ALKALINITY	SiO ₂
UDY	155-26E 24bad	2556	7.5	686	5.2	295	147	82
MW-3	-	5883	7.1	1753	5.6	572	48.5	122
CULINARY-3	-	2417	7.2	587	5.4	205	91.4	104
STEWART-1	155-26E 24bcd	2425	7.6	605	6.5	145	136	92
STEWART-2	155-26E 24cad	2136	7.2	525	1.3	337	159	82
STEWART-3	155-26E 25abb	2742	7.2	744	1.9	400	112	85
MILLAR-1	155-26E 27aba	950	7.5	150	5.7	230	168	94
CROOK (HOT)	155-26E 23ddc	5870	7.7	1767	7.1	288	26.1	118
CROOK (CULINARY)	155-26E 23ddc	1111	7.2	151	0.9	300	186	73
DARRINGTON CULINARY	155-26E 23acd	4236	7.3	1105	8.4	191	132	104
DARRINGTON-1	155-26E 23abd	4300	7.4	1065	6.7	235	97.6	100
DARRINGTON-2	155-26E 26cab	3680	7.7	966	6.9	104	86.8	102
DARRINGTON-3	155-26E 27dcc	1530	-	300	-	-	-	-
CULINARY-1	-	2211	7.3	543	6.2	160	87.8	92
BLM	-	3065	7.3	850	7.8	121	36.0	113
MW-1	-	11280	7.1	3510	5.8	470	21.2	110
WILLET(OLD)	145-27E 32bdd	4450	-	1255	-	-	-	-

NOTE: CONCENTRATIONS ARE IN µg/mL EXCEPT FOR CONDUCTIVITY WHICH IS IN µS

TABLE V
 AVERAGE VALUES FOR [Cl⁻] AND CONDUCTIVITY
 CHLORIDE MONITOR WELLS

Well Name	Type	Conduct. µmhos/cm	S _x	Cl (ppm)	S _x
UDY	irr.	2,556	±167	686	±80
MW-3	monitor	5,883	±305	1753	±67
Culinary-3	cul.	2,417	±106	587	±46
Stewart 1	irr.	2,425	±41	605	±43
Stewart 2	irr.	2,136	±74	525	±25
Stewart 3	irr.	2,742	±205	744	±48
Miller 1	irr.	950		150	
Crook	hot	5,870	±190	1767	±69
Crook	cul.	1,111	±101	151	±12
Darrington Cul.	cul.	4,236	±239	1105	±148
Darrington 1	irr.	4,300		1065	
Darrington 2	irr.	3,680	±45	966	±97
Darrington 3	irr.	1,530		300	
Culinary-1	cul.	2,211	±197	543	±44
BLM	hot	3,069	±167	850	±45
MW-1	monitor	11,280	±164	3510	±55
Willet (old)	irr.	4,450		1255	

TABLE VI
CHEMICAL CONCENTRATIONS AND STANDARD DEVIATIONS IN $\mu\text{g/mL}$

INEL ANALYSIS TO JANUARY 1977

Chemical Species	RRGE-1		RRGE-2		RRGE-3		RAFT RIVER		BLM WELL		CRANK WELL	
	\bar{X}	S_x	\bar{X}	S_x	\bar{X}	S_x	\bar{X}	S_x	\bar{X}	S_x	\bar{X}	S_x
CL ⁻	776	184	708	70	2170	302	153	70	1139			
F ⁻	5.32	1.47	8.25	1.06	4.55	0.25	0.65	0.21	5.6		4.11	
Br ⁻	<1.5		<1.5		<1.5		<1.5		<0.15		<0.15	
I ⁻	0.036	0.003	0.028	0.019			0.065	0.016	<0.040		<0.040	
*HCO ₃ ⁻	63.9	20.8	41.3	11.2	44.4	11.1	172.5	45.0	83			
SO ₄ ⁼	60.2	6.7	54.1	5.1	53.3	14.6	55.2	28.0	54		54	
NO ₃ ⁻	<0.2		<0.2		<0.2		3.8	<0.2				
Total NH ₃	1.56	1.19	0.60	0.41			1.0		0.59			
Total P	0.023	0.014	0.020	0.011			0.038	0.028	0.27			
S ⁼			0.256									
Si(OH) ₄	182	33	201	40	242	21	40.4	21.0	132		142	
Si	56.6	16.7	61.2	14.5	74.0	8.0	18.7	1.5	46		49	
Na	445	99	416	44	1185	52	77	26	550		1074	
K	31.3	7.0	33.4	5.3	37.2	7.3	7.7	3.7	20		34	
Sr	1.56	0.35	1.03	0.32	6.7	0.7	0.52	0.16	1.35		0.36	
Li	1.48	0.40	1.21	0.57	3.1	0.2	0.04	0.01	1.4			
Ca	53.5	9.5	35.3	8.7	193	15	85.3	29.6	55		130	
Mg	2.35	2.09	0.58	0.80	0.60	0.16	23.9	9.8	0.2		0.5	
pH							7.94	0.15				
Total Dissolved Solids	1560		1267		4130	36						
Conductivity	337		2742		3530	1546						
*Total Gas	33.4	21.9	35.4	22.1					12.9			
H ₂	0.10	0.14	0.67	0.69					0.11			
He	0.03	0.01	0.01	0.01					N.D.			
N ₂	30.6	20.8	18.8	7.1					12.4			
O ₂	0.13	0.17	0.27	0.56					0.05			
Ar	0.49	0.21	0.35	0.12					0.16			
CO ₂	1.91	2.48	1.01	0.63					0.15			

*HCO₃⁻ Concentrations are recorded in $\mu\text{g/mL}$ as CaCO₃.

*Conductivity is recorded in $\mu\text{mho/cm}$

\bar{X} Average Value

*Gas Volumes are in Standard cc/liter

S_x Standard Deviation of a Single Value

Try to get individual analyses used for $\mu\text{g/L}$ in RRGE-1 & RRGE-2.

RESULTS, CHEMICAL DATA EVALUATION

FROM THE FLOW TEST ON RRG1-6

TEST PLAN FET-12A-78

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&
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PURPOSE

The test was designed to define the hydrochemical and thermal characteristics of RRG1-6. This report will be concerned with the hydrochemistry. Chemical data were evaluated to determine changes in water composition during the period the well was idle and the temperature at depth increased from 70 °C to 123 °C.

TEST PROCEDURE

Geothermal well RRG1-6 flowed at a rate of 38-56 lpm for about 96 hours prior to testing. The purpose was to heat the well bore and to achieve a temperature equilibrium in the well bore. After the 96 hour preflow, the well was flowed at the maximum artesian flow of = 570 lpm for 18 hours. Water samples were collected at the beginning and at 4 hour intervals for the duration of the test. Also, an in-line conductivity probe monitored the conductivity of the water during the test period. Chemical analyses were performed on the water samples for pH, conductivity, HCO_3^- , CaCO_3 , Na^+ , and Cl^- concentrations.

DATA EVALUATION

The results of the analysis on the water samples are shown in Table I. Evaluation of the data indicate that there were no concentration changes in chemical species indicative of a trend. The average value of these analyses was compared to values of prior data, shown in Table I. With the exception of the Cl^- data collected November 8, 1978, these data compared very well. Evaluation

of the conductivity chart from the in-line conductivity probe showed no change in chemical characteristics during the test. The consistency in the results from the chemical analysis and the in-line conductivity monitoring indicates that the well had achieved chemical stability.

CONCLUSION

The preflow of the geothermal well RRG1-6 was adequate to achieve chemical stability. The evaluation of the chemical data and the in-line conductivity chart indicates no chemical changes that could be interpreted as a trend. Trends in chemical data would be the gradual increase or decrease of an individual species or all species analyzed. Such changes would be the result of pollution of the major production zone of a well by other production zones through the well bore or by deposition or chemical reaction. During the period of the flow test the accumulation of these pollutants would be flushed from the well bore. This would be evident in the change in concentrations of certain chemical species or all chemical species analyzed. Other support for achievement of chemical stability during the preflow period is the close correlation of data from samples collected during the chemical compatibility test on November 8, 1978 and samples collected during June 1978. The change of ≈ 40 °C in water temperature during the test is not reflected in the test or in prior analyses. The results of these analyses are shown in Table I.

TABLE I
 CHEMICAL DATA FROM
 FLOW TEST FET-12A-78
 ON RRG1-6

Collected November 9, 1978

<u>TIME</u>	<u>CONDUCTIVITY</u>	<u>Na⁺</u>	<u>Cl⁻</u>	<u>CaCO₃</u>	<u>HCO₃⁻</u>	<u>pH</u>
1113	10,050	2150	3640	398	70.20	7.32
2200	10,300	3210	3080	402	62.80	7.38
0200	10,000	2110	3630	416	75.72	7.66
0600	10,100	2270	3450	412	67.04	7.50
1000	10,200	2590	3130	398	62.60	7.40
1400	10,200	2000	3320	426	66.40	7.35
1800	10,300	2150	3400	408	70.00	7.45
\bar{x}	10,164	2354	3379	409	67.8	7.44
S _i	± 129	±421	±220	±10	±4.6	±.12
%S _i	1.3%	17.9%	6.52%	2.5%	6.8%	1.55%

Chemical Data Collected June 1978

10,567	ND	3272	407	60.3	7.3
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Chemical Data Collected November 8, 1978

10,500	ND	3915	428	62.8	7.5
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Values for chemical species are in $\mu\text{g/ml}$

ND = Not Determined

RESULTS, CHEMICAL DATA EVALUATION FROM THE FLOW WELL RRGE-2

INJECTING IN WELL RRG1-6 FOR 72-HOURS

TEST PLAN FET-22B-79

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R.L. Williams

I. PURPOSE

The test was designed primarily to check out test hardware and instrumentation and to define pump requirements for long-term testing. Chemical evaluation included determining possible chemical change in well RRGE-2 during the flow period and total weight of undissolved solids injected into well RRG1-6.

II. TEST PROCEDURE

Samples of well RRGE-2 water were collected at the injection well RRG1-6. Sampling frequency was about every eight hours. The samples were analyzed for conductivity, pH, hardness, Na, Cl⁻, F⁻, and alkalinity. Time lapse between sampling and analysis was less than 8 hours.

Filter samples of the suspended solids in the well RRGE-2 water were taken at the beginning of the test and approximately every 24-hours thereafter. Approximately 20 liters of sample water were flowed through a 2.0 micron sintered stainless steel filter. The filter had been cleaned, dried, and weighed prior to sampling. After sampling, the filter was returned to the laboratory, dried, and weighed. Determination of the residue weight was made.

Chemical monitoring of the water from well RRGE-2 took place throughout the flow test. A pH, oxidation-reduction and two conductivity probes were mounted in-line. The pH and oxidation-reduction probes failed early in the test. The conductivity probes functioned for the duration of the test. In addition to the conductivity being recorded continuously, readings were taken at ^{regular} specific intervals. *from the meters for the online probes.*

III. DATA EVALUATION

Table I shows the concentrations of the chemical species analyzed in the water samples collected at \approx 8-hour intervals during the test. Evaluation of this discloses that chemical changes between samples are random and not indicative of a trend. The average value and standard deviation for the concentration of each species were determined to establish the range of variation. The ~~percent of~~ standard deviation was less than 10% for all species except the bicarbonate ion.

The in-line pH, oxidation, and conductivity probes ~~are~~ ^{were} used to determine gradual changes in water chemistry. The pH and oxidation-reduction probes failed after \approx 28-hours of operation. The recorded pH indicated an upward trend with a Δ pH of \approx 1.0 for \approx 20-hours. It then shows a downward trend until ~~it~~ ^{The probe} failed.

The pH changes from in-line probes have been observed in other tests but the Δ pH was ~~smaller~~ ^{less}. It is difficult to evaluate this trend with the limited data obtained from the test. When the 21-day test on these wells takes place, the correlation of monitored pH data from both tests will be more meaningful. The recorded oxidation-reduction ~~recorded~~ ^{period prior to} data was linear through most of the ~~probes oper-~~ ^{probe failure} ~~ational time~~. There was a slight downward drift after about 26-hours of operation but it had begun an upward trend just before the probe failed. No other recorded oxidation-reduction data was available for comparison so it is difficult to determine if the change was a chemical change or instrument drift. The readings for the oxidation-reduction probe varied between -255^m mV to -270^m mV which means the water was a reducing media. Positive values are indicative of an oxidizing media. The conductivity recorder data show slight random drifts in both charts. The average conductivity for the probe located upstream from the injection pump was 1280 ± 103 μ S. This is an 8.0% variation from the average

conductivity reading. The average conductivity reading for the probe downstream from the injection pump had a reading of $1396 \pm 116 \mu\text{S}$. This is an 8.3% variation from the average conductivity reading. The 9.1% difference in conductivity between the two probes is due to slight differences in calibration and the different water pressures at which the probes operated. →

The pressure on the upstream probe was ~ 620 kPa and the downstream probe was ~ 1550 kPa.

Filter samples were collected at ~ 24-hour intervals. Figure 1 shows the results of the data. The shaded area represents the flow rate and time of flow. The solid line curve shows the change in suspended solids during the test. The suspended solids concentration increased throughout the test. No explanation will be given for this trend until the data from the 21-day test of these wells are evaluated. However, only 7.5 kg of solids (2.0 microns or larger) were injected with $13,000 \text{ m}^3$ of water into well RRG-6.

IV. CONCLUSIONS

Primarily the chemical data collected in the 72-hour injection of water from well RRG-2 into well RRG-6 is used to detect and determine chemical changes in the injection water. Evaluation of the data disclosed no apparent change in the water chemistry. There were no trends of chemical change observed. The determination of the weight of suspended solids showed that 7.5 Kg of solids were injected with the $13,000 \text{ m}^3$ of water into well RRG-6. The increase in suspended solids concentration as the test progressed could not be explained. However, in the longer injection test planned for the same wells, additional data will be collected from a modified test. This should assist in determining if the suspended solids are coming from the pipe lines between the wells or from erosion

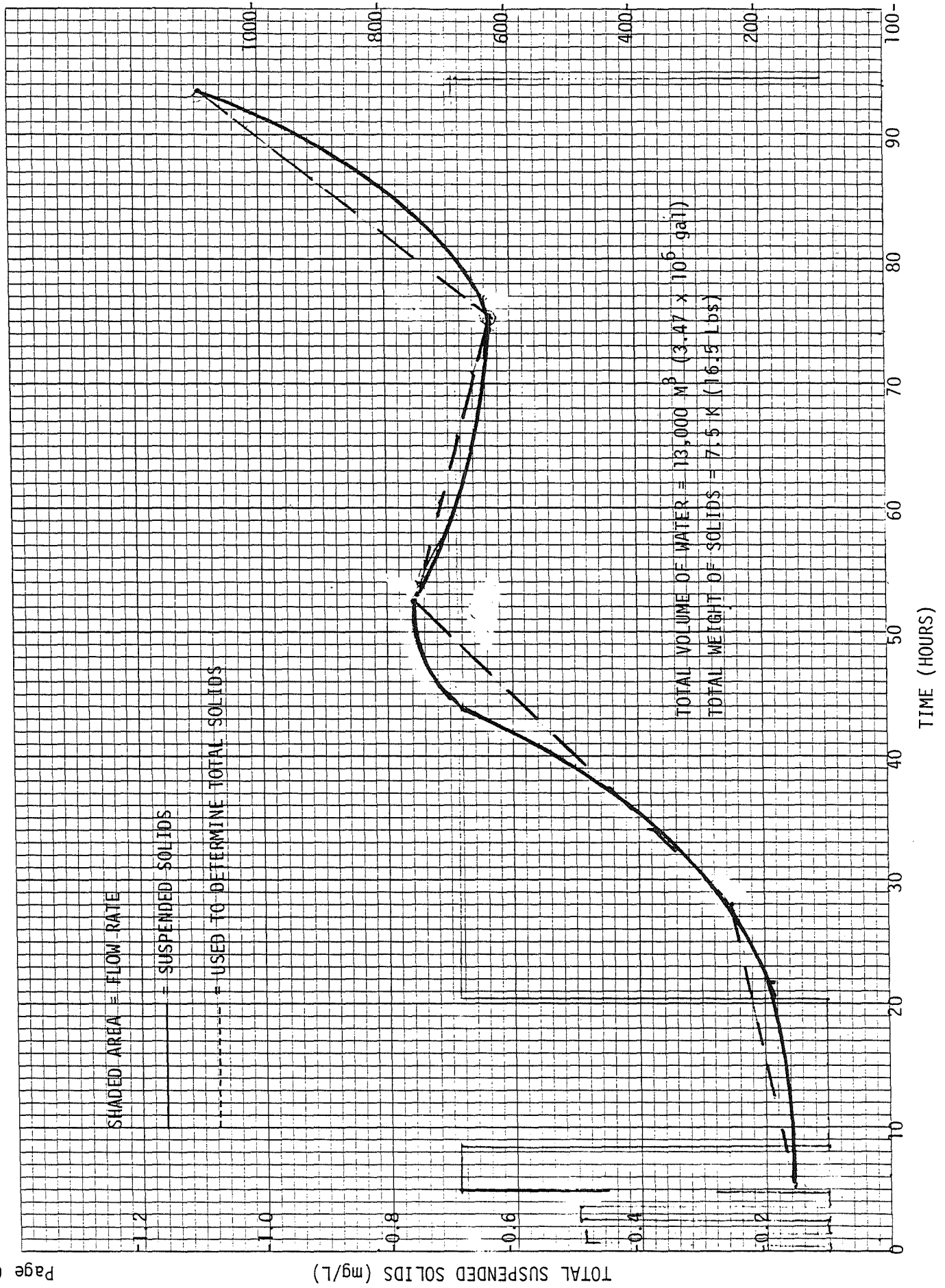
in the production zone of well RRGE-2. Some useful information was gained from the failure of the pH and oxidation probes. The cause of the failures will be determined, from this information, ⁺ The problem can either be corrected or other probes will be obtained that will operate in the rigorous environment of the geothermal water. Consequently, when the 5 MW power plant goes on-line, there will be a need for dependable in-line chemical probes. The well tests at the Raft River geothermal site presents the opportunity to prepare for this. It also gives the chemical and electronic technicians at the Raft River Geothermal Site an opportunity to become familiar with the equipment and train them to install, repair, and maintain this equipment.

TABLE I
WATER CHEMISTRY DATA
R. R. PRODUCTION TEST TO FLOW WELL NO. 2 INJECTING
IN WELL NO. 6 FOR 72-HOURS

DATE	TIME	CONDUCTIVITY	pH	As CaCO ₃ Ca ⁺⁺	Na ⁺	Cl ⁻	F ⁻	HCO ₃ ⁻
1-10-79	01:27	2400	7.95	110	386	750	9.33	51.60
1-10-79	08:30	2400	8.15	122	409	722	9.12	42.60
TEST TERMINATED PREVIOUS TO 08:30 SAMPLE								
1-10-79	23:25	2200	8.0	102	433	594	8.89	46.00
1-11-79	08:00	2300	7.45	102	479	616	8.47	40.00
1-11-79	13:00	2400	7.4	102	445	607	8.31	39.20
1-12-79	00:05	2400	7.95	104	408	677	8.65	33.6
1-12-79	08:00	2400	7.6	102	419	671	8.26	36.3
1-12-79	13:00	2400	7.15	108	479	620	8.30	44.00
1-12-79	23:20	2300	7.45	104	405	730	9.14	43.30
1-13-79	08:20	2300	7.5	90	430	614	8.11	38.40
1-13-79	19:00	2300	7.5	100	395	747	9.4	43.80
\bar{X}	--	2345	7.7	104	426	668	8.7	41.7
Si	--	± 69	± 0.3	± 8	± 32	± 61	± 0.5	± 4.9
% Si	--	± 2.9	± 4.1	± 7.5	± 7.5	± 9.1	± 5.4	± 11.9

NOTE: CONCENTRATIONS ARE IN $\mu\text{g}/\text{mL}$ EXCEPT CONDUCTIVITY WHICH IS IN μS

FIGURE 1.



Geochemical Results, Injection Test
at RRG1-7, FET-27-78

R. E. McAtee and Brenda Meyer

Introduction

The chemical testing at RRG1-7 included determinations of turbidity, conductivity, pH, and weight of undissolved solids in the injected water. Samples were collected at two-hour intervals from the pond at RRG1-7. They were collected between the line carrying water from the pond at RRGE-1 and the pump inlet. Revision of the test plan due to problems with the injection pumps eliminated inline conductivity measurements, inline pH measurements, and a sampling point downstream from the injection pumps. This will reduce the integrity of the results.

Purpose

The purpose of the turbidity and undissolved solids determinations was to compare the results and determine if there was good correlation. If so, turbidity measurements could be used to measure the total weight of undissolved solids injected during a test of the power plant operations. The pH and conductivity measurements were used to monitor the injection water for chemical change.

Results and Evaluation

Table I is a list of the results of the chemical measurements taken at the injection test for RRG1-7 and the hours that the samples were collected. The conductivity and pH measurements indicate only small changes in the injection water. This would be expected as the water was being pumped from the pond at RRGE-1. The small drop in conductivity resulted from the flow through the inlet system to the injection pump cleaning the system.

The turbidity measurements were very erratic and did not correlate well with the weights of undissolved solids. The only explanation is that the pond water had some organic discoloration that did not contribute to the weight of undissolved solids. Total undissolved solids injected into RRG1-7 were determined from the average value of the weight of undissolved solids and the total volume of water injected. Total weight of undissolved solids injected into RRG1-7 was 220 kg (480 lbs) in 6300 m³ (1.6 million gal.) of water.

Conclusion

The data included in this report is not of good quality due to the conditions in which the water samples were collected. The weight of undissolved solids would be a minimum value as the debris picked up in the immediate area of the injection-pump inlet would not be detected in the water samples. Hopefully additional correlation studies of turbidity and weight of undissolved solids will be made under more ideal conditions. These studies should make it possible to use an inline turbidity meter to monitor the undissolved solids being injected into the injection wells.

TABLE I
RRGI-7 Injection Test

<u>Date</u>	<u>Time</u>	<u>Conductivity</u>	<u>pH</u>	<u>Turbidity</u>	<u>Weight</u>
11-16-78	1900	3200	8.20	38	46.8
	1700	3600	8.16	56	28.5
	2200	3200	8.19	57	43.6
11-17-78	1100	3200	8.13	44	47.6
	1400	3200	8.21	40	32.7
	1700	3200	8.26	37	30.5
	2000	3100	8.24	32	23.0
	2300	3200	8.25	38	21.7
11-18-78	500	3000	8.22	48	35.0
	800	3100	8.21	34	21.7
	1100	3200	8.23	30	35.9
	1400	3100	8.19	44	39.5
	1700	3100	8.18	42	27.1
	2300	3100	8.27	44	23.0
11-19-78	500	3100	8.17	50	66.3
	1100	3100	8.17	48	29.9
	1700	2800	8.26	39	29.8
	2300	2800	8.23	48	43.6



INTEROFFICE CORRESPONDENCE

date January 5, 1979
to D. Goldman
from R. E. McAtee *REM*
subject FLOW TEST OF RRGP-4AB - REM-2-79

The hydrochemical results for geothermal well RRGP-4AB, Test Plan FET-10B-78, are attached. This information is to be included in the final report of the test.

SW

Attachment:
As stated

cc: C. A. Allen *C.A.A.*
~~D. W. Altman~~
M. R. Dolenc
B. S. Meyer
S. G. Spencer
Central File

RESULTS, CHEMICAL DATA FROM THE FLOW TEST ON
RRGP-4AB; TEST PLAN FET-10B-78

R. E. McAtee
R. L. Williams

PURPOSE

The flow test on geothermal well RRG-4AB was conducted to determine or estimate certain hydrological parameters. Hydrochemical information was obtained to establish if equilibrium of wellbore conditions was achieved. Other uses of the chemical data were the geochemical studies of the Raft River geothermal site and for environmental purposes.

EXPERIMENTAL PROCEDURE

The geothermal well RRG-4AB was flowed prior to testing to preheat wellbore and establish isothermal conditions at aquifer temperatures. The preflow had to be terminated due to sharp decreases in the wellhead pressure. The test consisted of the well flowing for 18 hours at a flow rate of \approx 130 lpm. Unfortunately, this was not adequate to properly flush the well so that chemical stability could be realized. Additional problems prevailed when the flow water began to flash in the wellbore after about 12 hours of flow due to the increased temperature and low wellhead pressure.

Water samples were collected every hour and analyzed for conductivity and pH. Every 8 hours, at the beginning and the end of the test, the samples were analyzed for conductivity, pH, Na^+ , Cl^- , F^- , alkalinity, and CaCO_3 . No in-line chemical monitoring probes were installed for this test.

DATA EVALUATION

Geothermal well RRG-5 flowed at 130 lpm for 18 hours for a total fluid volume of 140 m^3 . Table I shows the results of the chemical analysis for the water samples collected during the test. The hourly conductivity values

show a gradual increase for the first 5 hours of the test. The conductivity for the next 4 hours is constant. The conductivity for the 9th hour to the 12th hour of the test drops off gradually. Unfortunately, this may be due to downhole flashing and not a real chemical change in the borehole. After 12 hours of flowing, the chemical data becomes sporadic and is the result of irregular mixing of the steam and flashed water. The pH values for the test range between 6.4 and 7.0 excluding the values for the last 6 hours of the test. This is about 1.0-1.5 pH units lower than for the other geothermal wells at Raft River.

CONCLUSION

The 130 m³ of water flowed from RRGP-4AB over the 18 hour test period was inadequate to flush the well so chemical stability could be achieved. It would have required at least 600 m³ of fluid flow. In addition to this, the low wellhead pressure and the resultant flashing of the water in the wellbore decreased the integrity of the data so much that the analysis for the last 5 hours of the test was of no value. Included in Table I are the analyses of RRGE-1 pond water (which was used in drilling RRGP-4AB) and the drill water sample taken at 1611 m (assuming this to be representative of the aquifer water). These were included for comparison purposes only. No evaluations or conclusions were made at this time.

TABLE I
Flow Test of RRGP-4AB

Sample Time	pH	Conduct. μ S	Na ⁺ mg/l	Cl ⁻ mg/l	F ⁻ mg/l	Alkalinity mg/l	CaCO ₃ ppm
1355	6.8	4100	681	1470	6.44	35.6	232
1504	6.8	4000					
1630	6.9	3800					
1700	7.0	4000					
1800	7.0	4200					
1900	7.0	4300					
2000	7.0	4400					
2100	7.0	4400					
2200	7.0	4400	712	1670	6.67	36.0	224
2300	6.8	4400					
2400	6.7	4400					
0100	6.8	4300					
0200	6.4	3700					
0300	6.4	3400					

----- Started Flashing -----

0400	5.6	1800	(Samples below are irregular mixtures of steam and flashed water)				
0500	5.5	700					
0600	5.6	550	120	155	0.808	12.8	46
0700	5.8	2500					
0800	5.7	3500					
0900	5.6	1100	161	283	1.25	14.9	48

Analysis of RRGE-1 (Pond Water 12-25-78)

8.2	3000	522	949	8.19	48.	146
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Analysis of RRGP-4AB During Drilling at 1611 m Depth

8.6	4800	853	1630	6.87	50.	241
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INTEROFFICE CORRESPONDENCE

date January 5, 1979
to D. Goldman
from R. E. McAtee *REM*
subject FLOW TEST OF RRGP-5 - REM-1-79

The hydrochemical results of the flow test on geothermal well RRGP-5, test plan FET 14A-78, are attached. This information is to be included in the final report of the test.

SW

Attachment:
As stated

cc: C. A. Allen *C.A.*
~~D. W. Allman~~
M. R. Dolenc
B. S. Meyer
S. G. Spencer
Central File

RESULTS, CHEMICAL DATA COLLECTED DURING THE 18-HOUR
FLOW TEST OF RRGP-5, FFT-14A-78

R. E. McAtee

R. L. Williams

PURPOSE

The purpose of the flow test on geothermal well RRGP-5 was to test wellhead hardware, site pumps for a long-term test, and to determine or estimate geohydrologic parameters. Chemical measurements were made to determine when chemical stability was achieved and if any chemical changes were apparent during the flow test. The chemical data obtained from this test will have application in later studies on geochemical mixing models for reservoir characterization and wellbore characterization.

EXPERIMENTAL PROCEDURE

The flow test on RRGP-5 was modified to an 18-hour flow test with only hydrological and chemical data being collected. Water samples were collected every 30 minutes. All samples were analyzed for conductivity and pH. Samples collected at \approx 8-hour intervals were analyzed for pH, conductivity, Na^+ , Cl^- , CaCO_3 , and alkalinity. In addition to these chemical measurements, the conductivity was monitored by an in-line monitor for the duration of the test. A pH probe was installed for in-line monitoring but failed at the beginning of the test.

DATA EVALUATION

Table I shows the chemical analysis of the samples collected during the 18-hour flow test of RRGP-5. The flowrate was \approx 1100 lpm for a total volume of \approx 1200 m^3 . The volume of the wellbore is \approx 200 m^3 . The rule-of-thumb for flushing the wellbore, such that chemical stability will be achieved, is \approx 3 times the wellbore volume. This volume of water had flowed from the well between the start of flow at 9:00 AM and 6:30 PM. The conductivity

measurements in Table I indicate chemical stability at \approx 5:00 PM. Table II shows the chemical data for the 8-hour analysis. The mean concentration (\bar{X}), standard deviation (S_c), and percent standard deviation ($\%S_i$) values determined excluded the first two values for each species. These are values for each species after well RRGP-5 reached chemical equilibrium. The concentration values in Tables I and II do not indicate a trend in chemical change during the flow period after chemical stability is reached. The in-line conductivity probe chart showed no indication of chemical change. Table I compares conductivity readings of the two methods. The conductivity of the water samples is \approx 400 μ s higher than the in-line probe. This difference is due to the high pressure, high temperature environment of the in-line probe.

CONCLUSIONS

1. The 18-hour flow test of geothermal well RRGP-5 resulted in the discharge of 1200 m³ of water. This was adequate to insure chemical stability. No trends in chemical change were observed after chemical stability was reached.
2. Based on the limited chemical profile established in this test, the water from RRGP-5 is of the type found in RRGE-1, RRGE-2, and the BLM well. This was expected from its location.

TABLE II
8-Hr Analysis of RRGP Flow Test

<u>Time</u>	<u>pH</u>	<u>Conduct.</u>	<u>Na⁺</u>	<u>Cl⁻</u>	<u>CaCO₃</u>	<u>Alkalinity</u>
09:00	7.2	2500	479	754	124	35.2
13:30	7.2	2600	493	715	118	34.2
24:00	7.8	2700	477	822	130	33.2
08:00	7.5	2750	562	737	120	34.8
13:30	7.2	2750	527	802	126	35.0
24:00	7.1	2800	520	911	124	37.3
08:00	7.0	2700	532	863	126	37.5
13:30	7.3	2700	585	802	120	37.6
24:00	7.1	2800	520	822	140	39.2
08:00	7.2	2800	554	699	130	37.8
13:30	7.3	2800	520	828	128	37.6
17:15	7.2	2800	528	791	122	37.0
\bar{X}	7.3	2760	533	818	127	36.7
S_i	±0.2	+46	±29	±70	±6.0	±1.8
% S_i	±3.2	±1.7	±5.5	±8.5	±4.7	±4.9

Concentration values are $\mu\text{g/ml}$

Conductivity values are μs

TABLE I
Flow Test of RRGP-5, November 1, 1978
Test Plan FET 14A-78

<u>Time</u>	<u>pH</u>	<u>Conduct.</u> <u>(in-line)</u>	<u>Conduct.</u>	<u>Time</u>	<u>pH</u>	<u>Conduct.</u> <u>(in-line)</u>	<u>Conduct.</u>
09:00	7.2	2000	2500	01:00	7.5	2400	2750
10:30	7.4	2300	2500	01:30	7.5	2400	2700
11:00	7.5	2100	2600	02:00	7.5	2200	2700
11:30	7.5	2050	2550	02:30	7.4	2200	2700
12:00	7.6	--	2600	03:00	7.3	2200	2700
12:30	7.5		2600	03:30	7.2	2400	2700
13:00	7.4		2600	04:00	7.4	2200	2750
13:30	7.2	2100	2600	04:30	7.5	2100	2700
14:00	7.3	2400	2700	05:00	7.6	2100	2750
15:30	7.2	1950	2600	05:30	7.5	2100	2750
16:00	7.4	1950	2600	06:00	7.5	2100	2700
17:00	7.4	--	2700	06:30	7.5	2200	2700
17:30	7.6	--	2700	07:00	7.5	2200	2700
18:00	7.5	2350	2700	07:30	7.5	2200	2700
18:30	7.6	2000	2700	08:00	7.5	2400	2750
19:00	7.5	--	2700	08:30	7.5	2400	2700
19:30	7.6	2450	2700	09:00	7.6	2400	2750
20:00	7.6	2450	2700	09:30	7.4	2400	2700
20:30	7.5	2400	2700	10:00	7.5	2400	2700
21:00	7.5	2475	2700	10:30	7.5	2400	2700
21:30	7.5	2475	2700	11:00	7.5	2400	2750
22:00	7.8	2300	2700	11:30	7.5	2400	2700
22:30	7.5	2450	2700	12:00	7.5	2450	2700
23:00	7.5	2400	2700	12:30	7.5	2400	2700
23:30	7.5	2400	2700	13:00	7.5	2400	2700
24:00	7.8	2300	2700	13:30	7.2	2400	2750
24:30	7.6	2200	2700				

Conductivity values are μ s

INTEROFFICE CORRESPONDENCE

date January 29, 1979
to File
from R. E. McAtee *REM*
subject EVALUATION OF FILTER TEST DATA - REM-3-79

The attached report is an evaluation of the data from the filter tests conducted during the following injection tests:

- (1) Injection of RRGE-2 water into RRGE-4 on May 18, 1978
- (2) Injection of RRGE-3 water into RRGE-4 on March 21, 1978
- (3) Injection of RRGE-2 into RRGE-6 on January 10, 1979.

In general, the report evaluates the weight of undissolved solids in the well production zone and the wellbore. In two of the tests, evaluation is made of the particle size distribution between 0.45 - 230 microns. This data is important in designing filter systems for the injection wells.

SW

Attachment:
As stated

cc: ~~C. A. Alleg~~
M. R. Dolenc
D. Goldman
Central File

WEIGHT AND SIZE DISTRIBUTION OF UNDISSOLVED SOLIDS IN
GEOHERMAL WELLS RRGE-2 AND RRGE-3

R. E. McAtee

INTRODUCTION

This report briefly describes the experimental techniques and the evaluation of the weights and size distribution studies on undissolved solids in water from geothermal wells RRGE-2 and RRGE-3. The experimental data was obtained from injection tests where water from RRGE-2 and RRGE-3 was injected into RRGE-4 and water from RRGE-2 was injected into RRG1-6. The data has been screened to be representative of the resource water.

EXPERIMENTAL

The filters used in this test consisted of a series of stainless steel filters with 2, 15, 60, 90, 140, and 230 micron pore sizes. The 0.45 micron filter was a membrane filter. They were placed in high pressure stainless steel filter holders. The series of filter holders were connected to the sampling point in descending order of filter size. Approximately 20 - 100 liters of sample water were flowed through the filters. The filters tared prior to sampling were dried in an oven at 105 °C for three hours and weighed on an analytical balance. The undissolved solids in the filtered water were determined. The series of filters separated the undissolved solids into the following sizes: 0.45-15, 15-60, 60-90, 90-140, and 140-230 microns.

EVALUATION

Table I shows the data taken from the injection tests where water from well RRGE-3 was injected into well RRGE-4, water from well RRGE-2 was injected into well RRGE-4, and water from well RRGE-2 was injected into well RRG1-6. Data indicating undissolved solids from the flowlines to the injection wells

TABLE I
FILTER TESTS

RRGE-3

Filter Size (10 ⁻⁶ m)	Filter Weight (mg/l)					Av	%
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>			
0.45 - 2	0.28	**	0.82	**	0.55	10.8	
2 - 15	1.56	**	2.03	**	1.80	35.5	
15 - 60	1.69	**	0.46	**	1.08	21.3	
60 - 90	1.32	**	0.47	**	0.95	18.7	
>90	<u>0.83</u>	**	<u>0.67</u>	**	<u>0.75</u>	14.7	
Total	5.68		4.45		5.07		

RRGE-2

0.45 - 2	Lost	0.074	0.103	0.073	0.080	16.4
2 - 15	0.084	0.064	0.073	0.139	0.090	18.4
15 - 60	0.155	0.057	0.028	0.165	0.101	20.7
60 - 90	0.147	0.096	0.064	0.144	0.112	23.0
90 - 140	0.137	0.006	*1.158	*3.732	0.039	8.0
140 - 230		0.002			0.002	0.4
>230		<u>0.064</u>			<u>0.064</u>	13.1
Total	0.523	0.363	1.426	4.549	0.488	

*Large amounts of iron oxides present.

**Omitted due to large amounts of residues from the flowlines being present.

Total Weight from RRGE-2 to RRGI-6 Injection Test
FET-22C-79 (sampled every 24 hours)

(1)	0.155 mg/l
(2)	0.205 mg/l
(3)	0.755 mg/l
(4)	0.635 mg/l
(5)	1.097 mg/l

have been omitted. The data in Table I shows only the undissolved solids present in the wellbore and carried out of the production zone of the wells. Most important is the fact that 80% of the undissolved solids in both wells were less than 90 microns in size. Also the highest percentage of undissolved solids in well RRGE-3 was between 2.0 and 15.0 microns. The undissolved solids in the water from well RRGE-2 were more evenly distributed.

The 72-hour injection test where water from RRGE-2 was injected into well RRG-6 was filter sampled at the beginning of the test and approximately every 24 hours for the duration of the test. Referring to Table I, it is notable that as the test progressed the total undissolved solid increased. Unfortunately, size distribution was not determined.

CONCLUSION

Knowing particle size of the undissolved solids in water to be injected is important in determining filter size, designing filtering systems, and determining the impact on the production zones in an injection well. The studies of particle size conducted on the injection of well RRGE-2 water into well RRGE-4 and the injection of well RRGE-3 water into well RRGE-4 indicated that = 80% of the undissolved solids were smaller than 90 microns. Also in well RRGE-3, 35.5% of the undissolved solids were between 2.0 and 15.0 microns. This would require very small filters to remove the major portion of the undissolved solids. The size distribution of the undissolved solids in the two wells involved in the test indicates the need for similar studies of the other production wells and the storage ponds.

The filter study of the water from well RRGE-2 being injected into well RRG-6 indicated a trend of increasing amounts of undissolved solids as the test progressed. Unfortunately, the test was terminated before it could be determined if the increase in solids was the result of the wellbore being flushed of residual materials. A test plan involving these wells in a longer injection test is being designed. When the test is initiated, filtered samples will be taken. The trend observed in the test described in this report may be better explained when the results of the next test are obtained.

INTEROFFICE CORRESPONDENCE

date April 4, 1978
 to C. A. Allen
 from R. E. McAtee *RE McAtee*
 subject FILTER TEST - REM-3-78

This letter briefly reports the results of the filtering experiment conducted in conjunction with the reinjection test at the Raft River Geothermal site on the 3-21-78 and 3-22-78. Geothermal water was taken from Well #3 and injected in Well #4. On 3-21-78 approximately 64 m³ were injected in forty minutes at different flow rates. On 3-22-78 approximately 364 m³ were injected in 160 minutes at 2275 L/min. A volume of 24.2 liters of water from Well #3 were filtered at the well head during the test on 3-21-78. A volume of 4.4 liters of water from Well #3 were filtered at the injection pumps located at Well #4 on 3-22-78. The filtering apparatus was a series of filters in the following size and order; 90, 60, 15, 2 and 0.45 microns. This allowed the filtered residues to be separated into sizes of 60 to 90, 15 to 60, 2 to 15, and 0.45 to 2 microns. Table I shows the residue weights collected in each filter. Figures 1 and 2 show the percentages of each size for both collection points.

Table I

Filter Size 10-6 meters	*Well #3 mg/L	**Well #4 mg/L
0.45	0.87	1.49
2.0	2.12	8.12
15.0	0.56	6.54
60.0	0.51	6.41
90.0	0.72	51.6

- * Water from Well #3 collected at Well #3
- ** Water from Well #3 collected at Well #4

As Well #3 had flowed at a reduced-flow for several days and at a higher flow for several hours before the injection test, the residue sample collected at the well head of Well #3 was considered to be representative of the materials in the ground water. The residues collected at Well #4 were dominantly particles of 90 microns or larger and were probably materials picked up in

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the pipe line between the two wells. Analysis is being conducted on the 0.45 and 90 micron filter residues to determine their origin.

The filtering tests will be continued throughout the injection tests. From the results, a particle size distribution will be established for undissolved solids of the wells involved in the test. This information will assist in sizing filters for the reinjection wells.

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FIGURE 1 - FILTERING FROM WELL #3 LOCATION

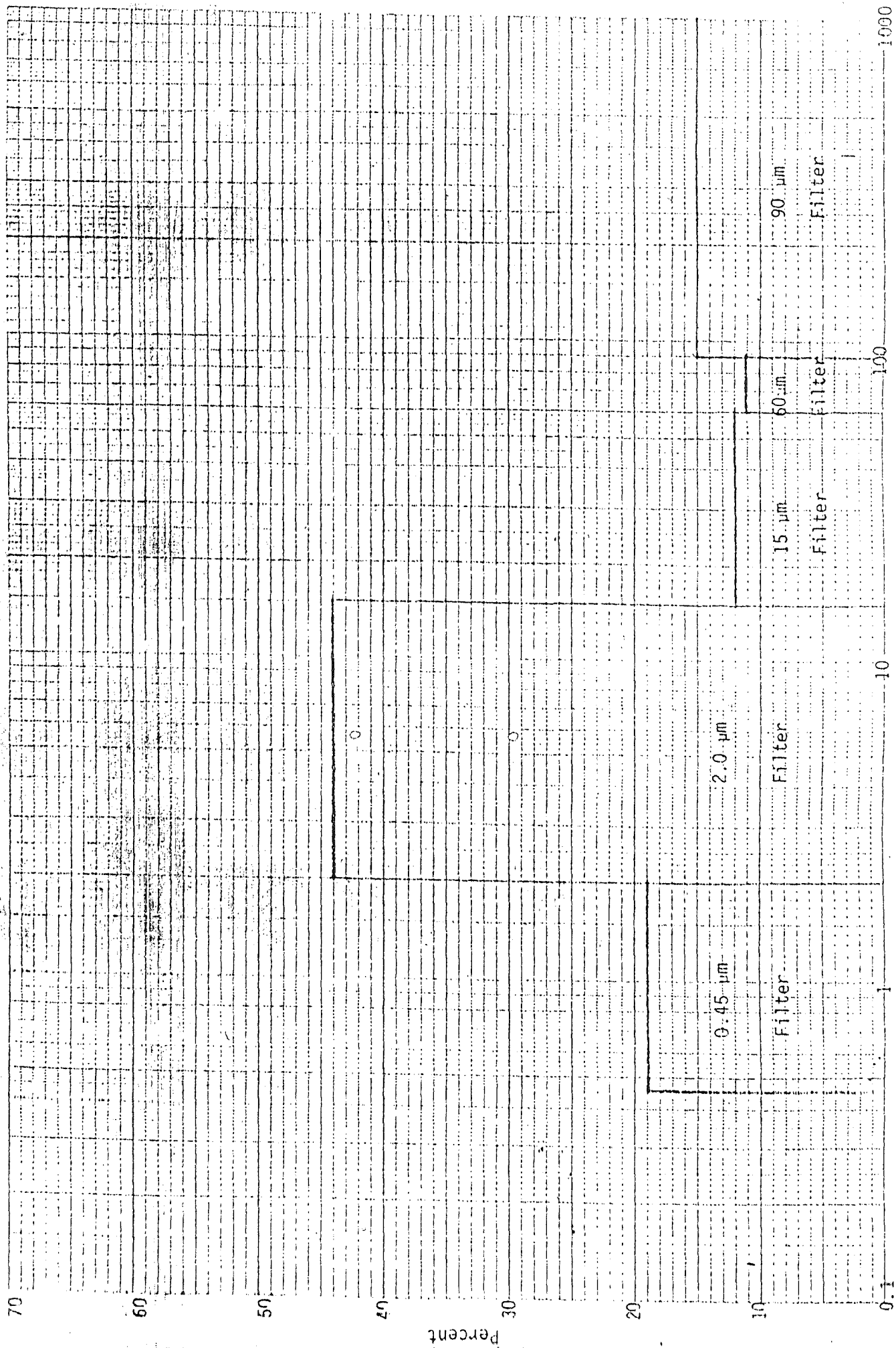


FIGURE 2 - FILTERING DATA FROM WELL #4 LOCATION

