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2.0 EXPERIMENTS AND TESTING AT RAFT RIVER - J. F. Kunze, L. G. Miller

2.1 Wells

Table I summarizes the uses of the three deep geothermal wells, at Raft River, over the six-month period (April to September 1977).

TABLE I

WELL USE - APRIL 1977 TO SEPTEMBER 1977

Well	Flow Rate	Wellhead Temperature	Uses
RRGE-1	3 to 16 liters/sec (50 to 260 gpm) (continuous use)	135°C (275°F)	Supplied water for corrosion and deposition experiments; cooling-tower-treatment experiment; fluidized-bed and direct-contact heat-exchanger tests; fish-farm, soil-heating, and irrigation experiments, and space heating.
RRGE-2	1 to 30 liters/sec (20 to 500 gpm)	133°C (272°F)	Underwent stepped well-performance tests to evaluate reservoir parameters. Well performed exactly as in the summer of 1975.
RRGE-3	1 to 48 liters/sec 20 to 800 gpm)	144°C (292°F)	Underwent well performance step testing to evaluate reservoir parameters. Down-hole pump installed and further step tests conducted. Compared to predictions from artesian testing, the pump testing indicated the well is better at high production rates than initially expected.
RRGI-4	36 liters/sec	163°C (352°F) (down hole)	In two tests after drilling, accepted injection up to capacity of drilling mud pumps, (32 liters/sec, 540 gpm). Flow tests were conducted to clean out cuttings prior to rig removal. Subsequently, production-flow tested at rates up to 200 gpm.

2.1.1 RRGE-3 Pump Tests

Pump tests were started on RRGE-3 on July 7. The pump used for testing is a REDA 320 ZP tandem-motor submersible at a depth of 236 m (773 ft). This pump is a second-generation pump designed for the flow rates of RRGE-1. After the testing is completed on RRGE-3, this pump will be checked for degradation, etc. It will then be installed in the first well.

A long-term test was started on July 6, at a flow rate of 600 gpm. This test was run for approximately 13 days, while monitoring temperature, pressure, well drawdown, and pump current.

Water samples were taken during all pumping tests, and analyses are being conducted at this time. An on-line pH detector monitored the well output pH throughout most of the test. Some variations were recorded, as seen in Figure 1. Water was discharged into the RRGE-3 reserve pit, a relatively large excavation used during drilling. The water did not get too deep during the two-week test, due to seepage and evaporation. At the request of the Idaho State Water Resource Department, the ground-water level and chemistry were monitored at two locations at opposite directions from the reserve pit, using the domestic well on the southwest and a monitor hole on the northeast. This monitoring will answer the question whether the ground water could be contaminated by the geothermal water seepage over long-term testing. Little evidence has been seen to date. The large volume irrigation pumping during summer months causes the ground-water level to continually drop.

2.1.2 RRGI-4 Drilling

The fourth Raft River geothermal well, RRGI-4, was designed for injection at intermediate depth. This zone was selected for injection so that researchers could study the interation of that strata with the shallow ground-water aquifer and the deep production zone. If results are as expected, both injection well and pipeline costs will be substantially reduced. The well is located approximately 0.8 m (1/2 mile) south of RRGE-1. This area was chosen because the land was available, the hydrology was better understood, because reservoir engineers suspected major upward leakage from the production zone--allowing them to monitor and study the connections between the reservoirs below RRGE-1 and RRGI-4.

Drillers began work on April 8, drilling with a 38-cm (15-in.) bit and reaming to 66 cm (26 in.). On April 10, 122 m (400 ft) of 51-cm (20-in.), K55, 94-lb surface casing were set and cemented to the surface. A 31-cm (12-1/4-in.) hole was drilled to 582 m (1909 ft), logged and cored, then reamed to 44 cm (17-1/2 in.). At a depth of 577 m (1894 ft) a core was attempted, using the Joides quadracone core-bit system on loan from LASL. During the trip into the hole with the corebarrel, the 30-cm (12-in.) O.D. corebarrel stabilizer became stuck at 438 m (1436 ft). Bit depth was 438 m (1474 ft). Back-off shot service was used to disengage

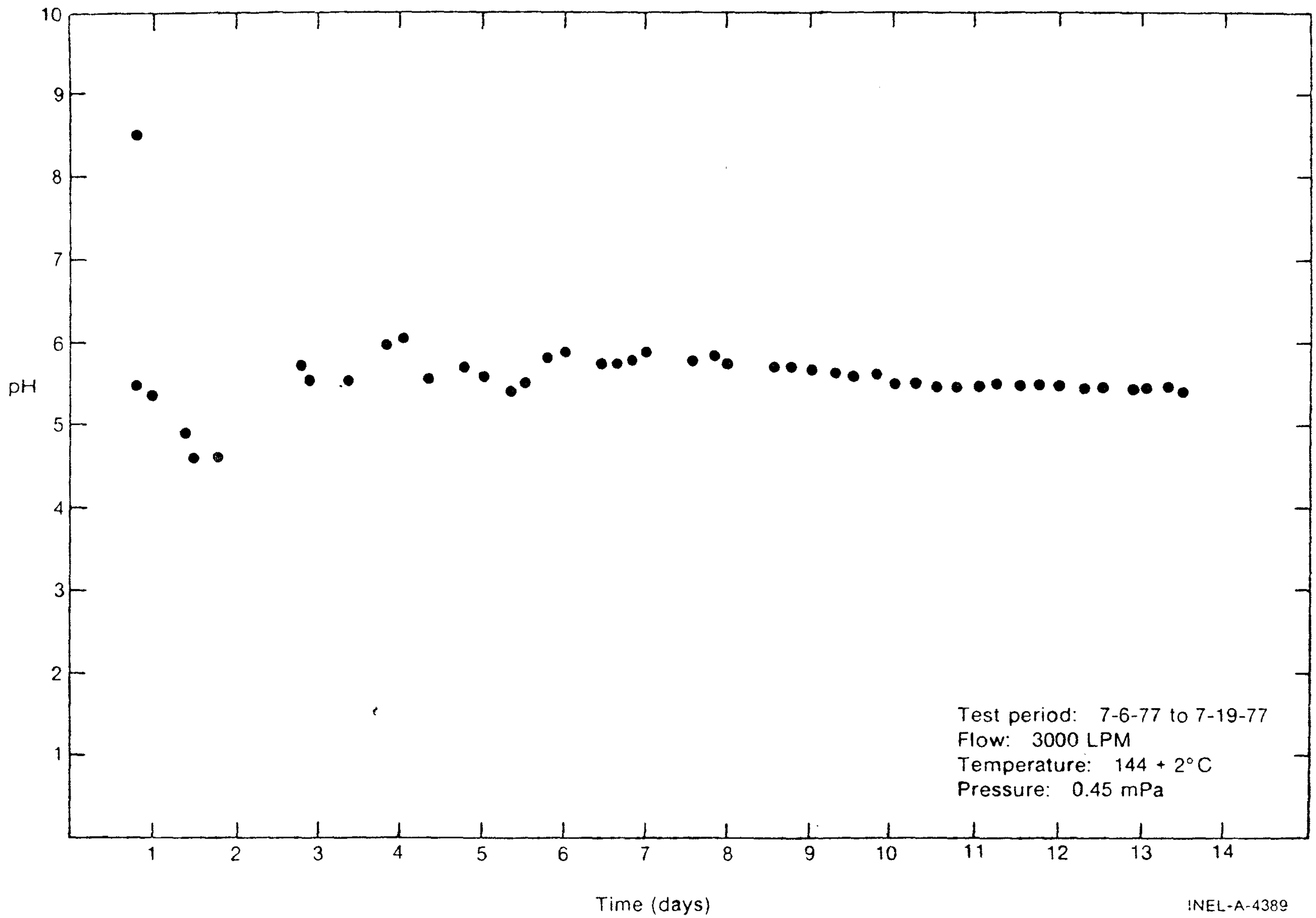


Fig. 1 Pump tests at RRGE-3

the drill pipe from the coring assembly. The assembly was recovered by using jars and bumper sub to free the stabilizer.

At a depth of 579 m (1901 ft), 34-cm (13-3/8-in.) K55 54.5-lb casing was run and stage cemented. The shoe was drilled out with a 31-cm (12-1/4-in.) bit and drilling proceeded to a depth of 643 m (2110 ft). At this depth, it was necessary to trip out for a new bit. Prior to drilling, the decision had been made to core at selected intervals; this coincided with trips for a new bit. During the trip in with the corebarrel, an obstruction was encountered at 575 m (1887 ft). Milling tools were used, accomplishing only sidetracking around the obstruction. Logging determined the obstruction to be the 34-cm (13-3/8-in.) casing shoe, float collar (one joint up) and two joints of casing which parted and fell 25 m (81 ft). With a fishing spear, an attempt was made to jar the casing loose and let it fall downhole, hopefully creating a more vertical entry through the casing. The casing could not be moved. Attempts to pass the bit and string through the parted casing were made and were successful three times, enabling drilling to proceed to a depth of 860 m (2820 ft). A second core was taken from 860 to 866 m (2820 to 2840 ft).

Predrilling parameters had been set. Maximum total depth would be 1067 m (3500 ft), and the maximum bottom-hole temperature was to be 122°C (250°F).

Temperature logs taken during this period show temperatures of 114°C (237°F) at the top of the parted casing and 122°C (252°F) at 823 m (2700 ft). Artesian flow had reached 250-300 gpm. The decision was made to terminate drilling. Prior to releasing the rig, four joints of 24.4-cm (9-5/8-in.) casing were passed through the parted 34-cm (13-3/8 in.) casing to verify that the well could be deepened and completed as a production well at a later date. Temperature-log data is shown in Figure 2.

Two short injection tests were run, to verify predicted injection capacities of the well, prior to releasing the drill rig. Tests were designed to measure the wellhead pressures required to inject fluids at various rates. The amount of injected fluid was limited to prevent its entering the formations. The first test duration was 4-1/2 hours, utilizing the rig pumps. (See Figure 3 and Table II for Injection test No. 1 Results; see Figure 4 and Table III for Injection Test No. 2 Results.)

The second test was run within 24 hours of the first test. The flow rate was a steady 252 gpm over five hours. The well was cool, as indicated by the initial wellhead pressure of 19 psi. It dropped to 8 psi when the well was shut in at the close of the test.

2.2 Pipelines and Site Facilities

2.2.1 Pipeline from RRGE-3 to RRGE-1 Site

The design of this 2743 m (9000-ft) pipeline was completed, bids let and awarded, and construction started this quarter. This pipeline,

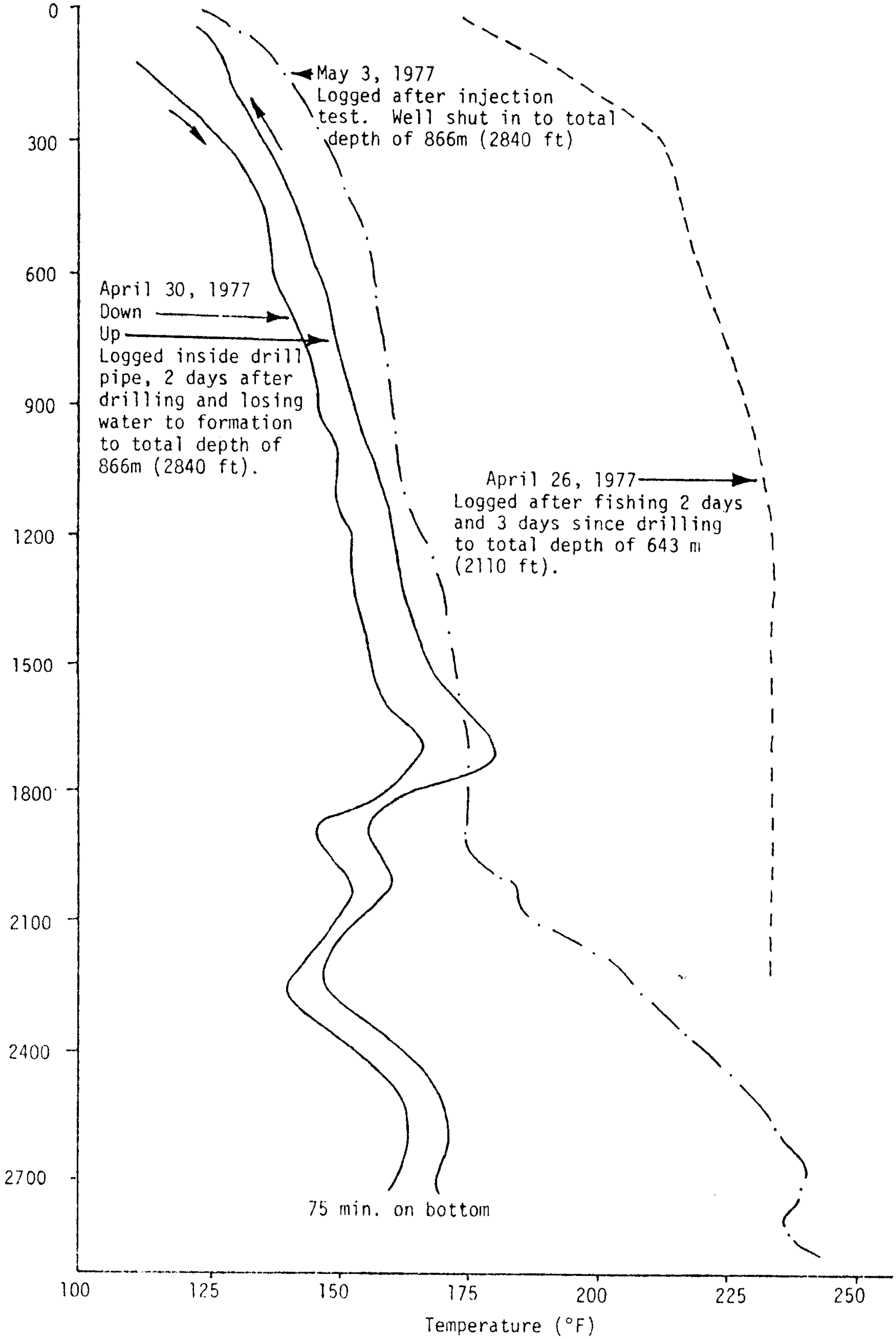


Fig. 2 RRGI-4 temperature logs

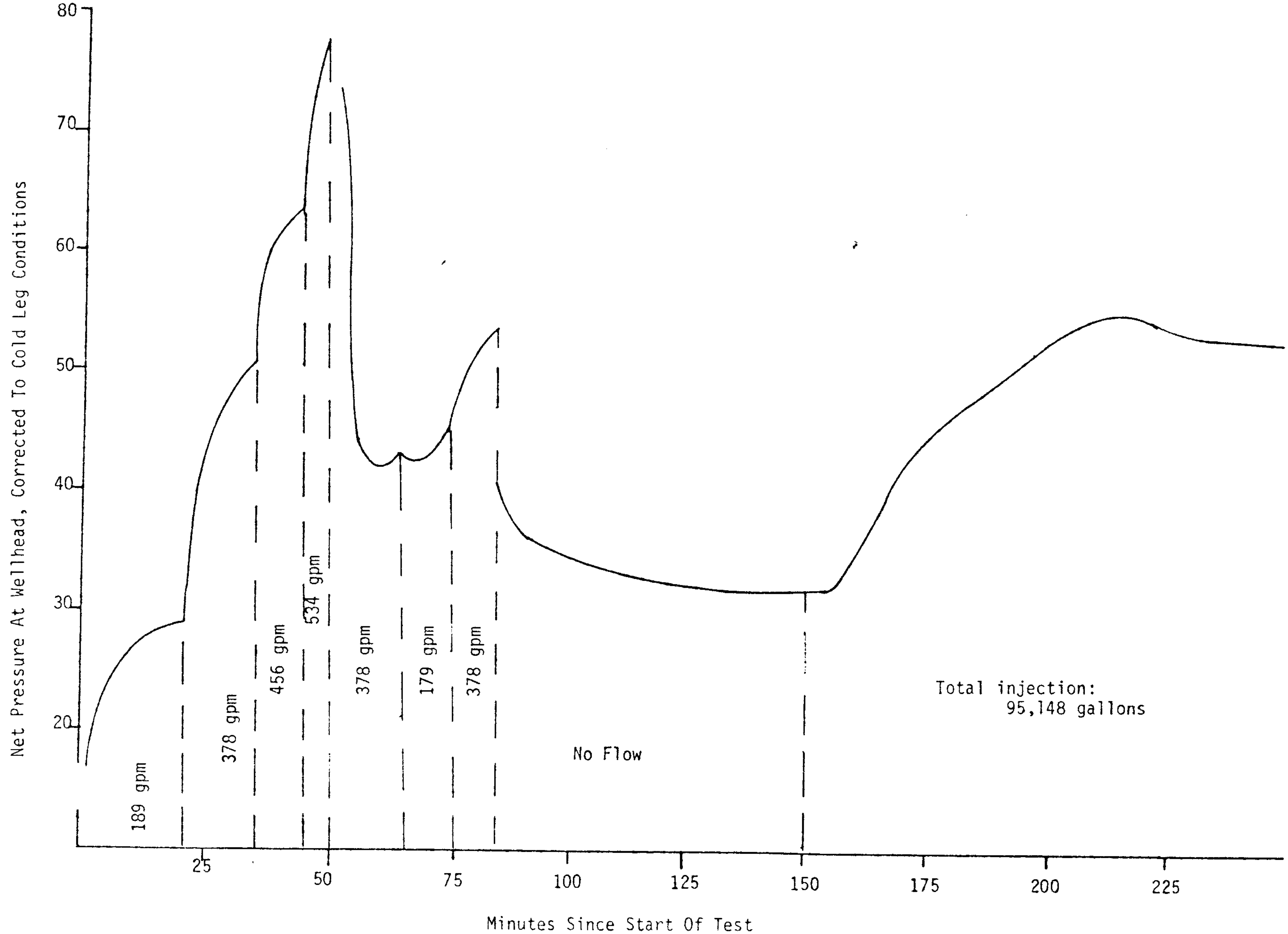


Fig. 3 First injection test on RRGI-4 - May 3, 1977

TABLE II

RRGI-4 INITIAL INJECTION TEST RESULTS

Time [a]	Wellhead Pressure (psig)[b]	Pump Rate No. 1[c]	Pump No. 2 Rate [d]	Total Rate (gpm)
0033	32	0	0	0
0034	32	30	30	189
0054	49.5	"	"	"
0055		60	"	378
0056	62	"	"	"
0108	59	"	"	"
0109		60	30	456
0110	65	"	"	"
0119	63	"	"	"
0120		60	60	534
0121	77	"	"	"
0124	78.5	"	"	"
0125		60	0	378
0127	70	"	"	"
0138.5	43.5	"	"	"
0139		30	0	189
0141	43	"	"	"
0148	44	"	"	"
0149		60	0	378
0150	47	"	"	"
0159	54	"	"	"
0159.5		0	0	0
0200	42	0	0	0
0300	32	0	0	0
0310		45	"	283.5
0320	40	"	"	"
0500	55	"	"	"
			Total gallons injected	95,148

[a] Selected intervals.
[b] Shut-in wellhead pressure was 32 psi.
[c] No. 1 pump 6.3 gal/stroke.
[d] No. 2 pump 2.6 gal/stroke.

Pumping rates and wellhead pressure went from 50 psi wellhead pressure at 189 gpm to 78.5 psi at 534 gpm requiring ΔP of 46.5 psi.

The aquifer rapidly returned to normal after being shut-in as indicated by a drop from 42 psi to 37 psi in 5 minutes and normal 32 psi in less than one hour.

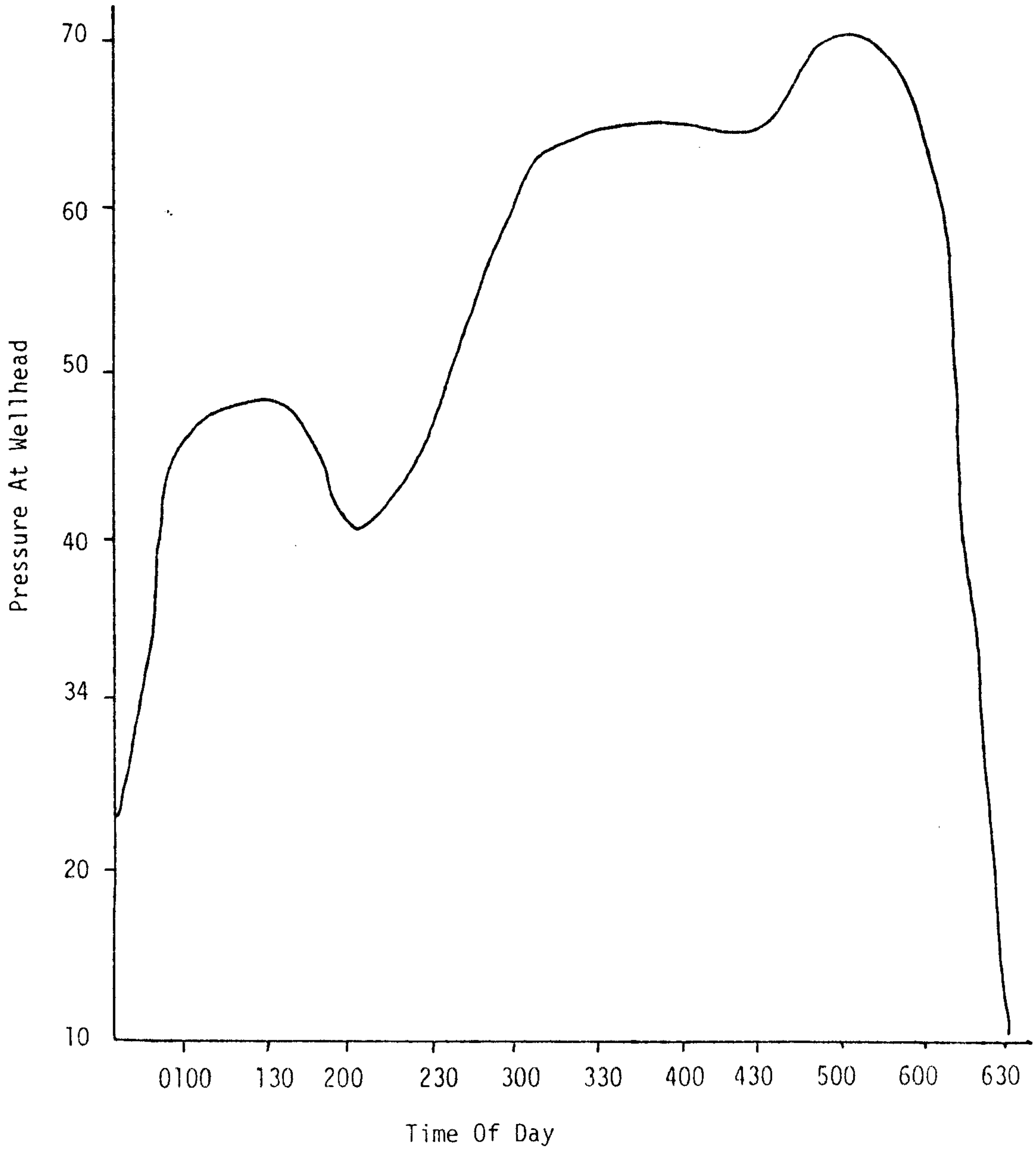


Fig. 4 Second injection test on RRGI-4 - May 4, 1977

TABLE III

RRGI-4 SECOND INJECTION TEST RESULTS

(Cold Well)

Time	Wellhead Pressure (psig)	Pump Rate	Total Rate GPM
0055	19 psi	0	0
0100	46	45	252
0130	48	45	"
0200	41	"	"
0230	46	"	"
0300	62	"	"
0330	65	"	"
0400	65	"	"
0430	65	"	"
0500	70	"	"
0530	60	"	"
0600	8	0	0
		Total gallons injected	120,960

The ΔP during this test was 51 psi with a high of 70 psi after four hours then dropped to 60 psi at the end of the test as well cooled off.

when completed in late August, will allow the higher salinity geothermal fluids (by a factor of two over RRGE-1 and RRGE-2) of RRGE-3 to be utilized in the test trailer at the RRGE-1 site. The pipeline has the flexibility to allow:

1. the fluid from RRGE-3 to be discharged into the RRGE-3 reserve pit,

2. the fluid to be delivered to the RRGE-1 site, or

3. fluid from RRGE-1 or RRGE-2 to be transported to RRGE-3 and discharged into the RRGE-3 reserve pit.

The pipeline is sloped from both sites to the middle (near the river), where pipe connections will allow draining of either half or the full pipeline for repair or other requirements. This pipeline is being installed with a minimum of 2.54 cm (1 in.) of polyurethane foam insulation sprayed on after the pipe has been installed in the trench. The pipeline is constructed of 25.4-cm (10-in.) transite pipe buried 76 cm (30 in.) below the ground level. Most above-ground piping and valves are 20 cm (8 in.) spray insulated similar to the buried transite pipe. The use of 2.54-cm (1-in.) thick urethane insulation with pipe buried 76 cm (30 in.) will effectively reduce the heat loss by a factor of at least two--even more for conditions of wet soil. A flow of 1000 gallons/minute through the 25.4-cm (10-in.) transite pipe (4.8×10^5 lb/hr) results in the following:

Heat loss per mile of pipeline = 1.32×10^6 Btu/hr (equivalent to 48 kW of electricity at 12-1/2% conversion efficiency)

Fluid temperature loss per mile of pipeline = 2.75^oF.

2.2.2 Pipeline from RRGE-1 Site to RRGI-4

Design of the pipeline portion of this task is near completion. The A&E work on this pipeline is being done by CH_2M-Hill at Boise, Idaho. Conceptual design of the injection pumping, monitoring, and filtering system is near completion, with reviews being conducted by personnel from East Mesa and the USGS.

This 30-cm (12-in.) polyurethane-foam-insulated line will transfer fluids from the RRGE-1 site to the RRGI-4 site for injection into that intermediate-depth injection well. This work is expected to be completed late in October. Full-scale injection tests can begin upon completion of this system.

The low pump pressures obtained from these short tests are very encouraging. Before full-scale injection begins, the well will be artesian flowed to clean cuttings and debris from the producing formations.

The well was then flow-tested for production under artesian conditions. Because of its intermediate depth and low production temperature (122°C, or 252°F), the artesian pressure is much lower than that of the other three wells. RRGI-4 has a pressure of approximately 20 psi when at equilibrium and 50 psi when hot. The transmissivity, or permeability-thickness product of the producing zone (which appears to be between 579 m and 732 m (1900 to 2400 ft) is about the same as that of RRGE-2--about 15,000 millidarcy ft.

Table IV describes RRGI-4 and provides a chronology of drilling experience.

Tests are being conducted on the outlet water from the tube-and-shell heat exchanger test. Approximately 60,000 gallons of geothermal discharge fluid was diverted through screens to determine the size of particles discharged from the pilot plant heat exchangers. Only a couple of sand grains were caught in the screen. The screen openings are approximately 0.036 cm (0.014 in.) square. Further tests will be conducted on particulates in the geothermal fluid.

2.2.3 Pilot Plant Site Location

An area has been selected southwest of the RRGE-1 site for the location of the 5 MW pilot plant. This area has the following advantages over other areas considered:

1. It is near what is considered the center of the resource area. Therefore, pipeline costs will be reduced.

2. This area has two distinct elevations, so that the shop, control building, and cooling tower can be located at a higher elevation than the isobutane systems. This arrangement will produce better cooling-tower performance and ensure safety from isobutane leakage.

3. Large areas of relatively flat land are available adjacent to the facility for the cooling pond, soil cooling and other facilities.

4. Services and facilities located at the RRGE-1 site will be close, thus reducing costs.

5. A common fire-control system can serve both areas.

6. The site area and adjacent land are owned and controlled by BLM.

2.2.4 Aquaculture Facility - J. W. Neitzel

The design and construction of the Raft River aquaculture facility was completed. The system consists of a series of indoor

TABLE IV

SUMMARY OF RRGI-4 CHARACTERISTICS AND DRILLING EXPERIENCE

Location:	610 m (2000 ft) S of RRGE-1, in SE 1/4 S 23 T 16S, R 23 E Elevation = 1474 m (4835 ft)
Depth and Casing:	
51-cm (20-in.) surface casing to	122 m (400 ft) [a]
34-cm (13-3/8-in.) production casing to	555 m (1820 ft)
Open hole 24.4 cm (9-5/8 in.) to	866 m (2840 ft)
Production Zone Temperatures :	
579 m (1900 ft)	111^{o}C (232^{o}F) minimum
762 m to 853 m (2500 to 2800 ft)	122^{o}C (252^{o}F) minimum
Drilling Experience:	
Spudded, began drilling	April 8, 1977
Cemented surface casing to 122 m (400 ft)	April 11, 1977
Drilled out of surface casing	April 12, 1977
Reached 582 m (1909 ft)	April 19, 1977
Cemented production casing	April 20 and 21, 1977
Drilled out of production casing [at which time bottom 24 m (80 ft) of casing - two joints - were found to be loose in the hole]	April 22, 1977
Reached TD of 866 m (2840 ft)	May 1, 1977

[a] All distances are distance from ground level

rates and bearing materials. The 244-m (800-ft) setting even further complicates these problems.

Other design requirements include a flow rate of 800 gpm with a discharge pressure of 150 psi at the surface of the well. Special material requirements were also given, based on test results obtained at the Raft River test-facility. The following materials, for instance, were found to be unacceptable for use in the geothermal fluid because of their susceptibility to corrosion: copper-nickel alloys, aluminum-base alloys, and martensitic stainless steel.

In May 1977, a request for price quotations was sent to the five pump suppliers who showed interest in supplying a geothermal vertical-turbine pump. The companies responding with a quotation were Johnston Pump Company and Peerless Pump Company. The two quotations were reviewed, and Peerless received the award at a low-bid price.

Peerless has been involved with the pumping of geothermal brines from deep wells since 1969. They have pumped brines up to 190°C (375°F) at rates up to 1200 gpm and with pumps set as deep as 213 m (700 ft). Their experience in various projects has given them an overview of the problems of corrosion, erosion, thermal expansion and scaling. With this experience, they are well qualified to supply a deep-well vertical-turbine pump for geothermal service at Raft River.

The Floway Pump Company of Fresno, California, was also contacted as a possible supplier. Floway has supplied pumps and pump components to the Iceland geothermal facilities for the past ten years. With their experience in mind, they were contacted by telephone to determine their interest and to obtain an engineering estimate. It was found that Floway could provide a deep-well vertical-turbine pump to meet the design; however, their deep-well pump would not be capable of supplying the 150 psi wellhead pressure at the 800 gpm flow rate. Their design therefore calls for a booster pump at the surface to bring up the pressure at an additional cost of approximately $20,000. With the added cost, and with installation problems involved with the second pump, Floway could not compete with the Peerless design and cost.

2.3 Reservoir Engineering - R. C. Stoker

2.3.1 RRGI-4 Coring and Logging

RRGI-4 was drilled and cored during April. Two cores were taken, one at 579 m (1900 ft) and the other from 862 to 865 m (2828 to 2838 ft). Total depth of the injection well is 866 m (2840 ft). The effective water porosity at 579 m (1900 ft) is 24.5%, and the permeability is 60.0 millidarcies. The sample from around 863 m (2833 ft) has an effective water porosity of 28.5% and a permeability of 0.20 millidarcies. See Table V for the latter test results.

Several temperature logs were taken of the well, in addition to compensated neutron/gamma, acoustilog/gamma, densilog/gamma/caliper and

TABLE V

RRGI-4 POROSITY-PERMEABILITY TEST RESULTS

SAMPLE DESIGNATION	WET BULK DENSITY (gm/cc)	DRY BULK DENSITY (gm/cc)	GRAIN DENSITY (gm/cc)	TOTAL POROSITY (%)	EFF. WATER POROSITY (%)	CONFINED WATER PERMEABILITY σ_3 = 2800 psi
2842.25'	2.28	2.03	2.66	24.0	23.0	280μD .28 milli
2844.08'	2.45	2.34	2.69	13.0	13.0	10μD .01 milli
2847.5'	2.54	1.93	2.70	28.5	28.5	16μD .016 milli
2850.3'	2.31	2.16	2.67	19.0	19.0	80μD .08 milli
2852.6'	2.39	2.01	2.70	25.6	23.0	40μD .04 milli

dual-induction/spontaneous potential. All applicable logs were digitized for future analysis. These logs were taken from ground level to the 579-m (1900-ft) depth. Logging from 579 m (1900 ft) to total depth of 866 m (2840 ft) ground level has been attempted but has been unsuccessful because of the displaced casing at the 579-m (1900-ft) depth.

All drill cuttings from RRGI-4 were examined during drilling, and a good correlation was established between RRGI-4 and RRGE-1. Cross sections of all four Raft River wells are shown in Figure 6.

2.3.2 RRGE-3 Logging

Logging was completed in RRGE-3 by running logs in Leg C. A complete set of logs was run, including compensated neutron/gamma, temperature, dual induction/spontaneous potential, acoustilog/gamma/caliper, densilog/gamma/caliper and spectralog. The spectralog indicated unusual amounts of potassium (K-spor) around 1402 m (4600 ft) with some increase in uranium. Another interesting interval occurred in the metamorphed zone from 1646 to 1676 m (5400 to 5500 ft); logs again showed increased amounts of potassium and uranium. However, the most interesting interval occurred in the Quartz Monzonite below 1768 m (5800 ft). This zone showed an increase in thorium and a particularly large increase in uranium.

2.3.3 RRGI-4 Future Injection Tests

In order to properly evaluate future injection testing in the RRGI-4 well, baseline data is required for the area around the well. Pressure instrumentation has been established in the USGS No. 3 hole, and more data is being gathered on other surrounding wells. Further long-term injection testing will be conducted in FY-78.

2.3.4 INEL Logging Truck

The logging truck underwent major modifications in order to upgrade the logging capability and efficiency and provide improved all-weather logging ability.

2.4 Environmental Program at Raft River

The environmental report for the Raft River pilot power plant was used in June. The draft report had been offered for review to the following agencies and environmental-interest groups: U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, Idaho Department of Water Resources, Idaho Department of Health and Welfare, Sierra Club, Idaho Conservation League, Wilderness Society, and environmental program contractors within both the Idaho and Washington Offices of the Department of Energy. Personnel from Dames and Moore and from Stafco served as technical advisors for the report. The final report, as well as an assessment of potential geothermal developments (other than those involving DOE) in Raft River was issued in June.

2.4.1 Species of Concern

The major concern identified by the reviewers of the environmental report was for the preservation of the ferruginous hawk. In light of the concerns that have been expressed in the past by both the BLM and the Fish and Wildlife Service, the Raft River environmental program continues to support the Fish and Wildlife Service monitoring of nesting raptors in the Valley. An aerial survey of the nests between Almo and the northern end of the Valley was conducted in May. Preliminary data from the survey, as well as for past surveys, are summarized in Table VI. Surveys of this type will be taken periodially. The U.S. Fish and Wildlife Service has received funding to expand the study to include research on disturbance-effect patterns. This work began in March 1977.

The Department of Zoology at Brigham Young University was awarded a contract to supplement the initial baseline studies of small mammals, avians, and insects in the vicinity of the geothermal development. A large grid with nearly 300 traps was established for the small mammal work. As the study progressed, some traps were moved to ten vegetation communities identified in previous work by the University of Utah Research Institute (UURI). Animals at these sites are being sacrificed and examined for reproductive characteristics. The grids were partially sampled again in June and July; the intensive trapping was repeated in August. Plots for the avaian study were established on all four sides of the geothermal development area and tied into the vegetation plots. Four major passerine (songbird) species, the Sage Thrasher, Brewer's Sparrow, Sage Sparrow, and Horned Lark, were used as indicator species. Nesting density and species-composition data were used as indices to monitor changes. The ant-aphid system was chosen for an intensive insect study because they are closely responsive to vegetation changes. Selected rate variables were examined and a model of the system was developed. Permanent monitoring stations have been established so that future impact assessments can be related to baseline data. A summary report of the 1977 studies will be available in January 1978. Similar studies will be conducted during 1978.

The first year of the UURI vegetation study was completed. A summary report was issued, and the most relevant data were included in the overall environmental report. Approximately 29,000 ha (72,000 acres) were mapped and 13 major types of vegetative cover were distinguished. The dominant life forms are shrubs, such as greasewood, sagebrush, and saltbush. Nineteen "permanent" plots were established and are being surveyed again this summer.

2.4.2 Particulates

Particulates collected by UURI in the venting plume at RRGE-2 in December 1976 have been analyzed. The particulates did not consist primarily of sodium and chloride ions, as expected from the ion content of the geothermal waters. This result indicates that the liquid droplets containing the geothermal salt were not collected by the filter, and/or other particulates far exceeded these in quantity. Results of the distribution, and the elemental composition of the collected particles are as follows:

TABLE VI

BREEDING DYNAMICS OF FERRUGINOUS HAWKS IN THE STUDY AREA

Year	No. Pairs	Nesting Attempts	Successful Nests	No. Young	No. Fledged	Nesting Success (%)
1972	43	38	31	89	84	85
1973	54	27	23	58	56	81
1974	42	--	18	42	40	--
1975	--*	--	19	48	46	--
1976	--	28	21	57	54	75
1977	35	29	18	51	48	62

* No data

Size (microns)	%/No.	Elements present
< 2	65	Si, Cl, Fe
2-4	18	Si, Fe, K
4-6	10	Si, Ca, K, Fe
6-8	6	Si, Fe, Ca
8-30	6	Si, Cl, K, Ca, Na

Particles in water samples from RRGE-2 and RRGE-3, produced by a particle generator, ranged in size from 1 to less than 0.2 micron. The majority of these particles were cubical, and only chlorine and sodium could be detected with energy-dispersive X-ray analysis. Table VII lists the size range distribution by number and mass. The concentration of these submicron sodium chloride particles was determined to be from 13 to 14 mg per liter of well water.

These small salt particles are similar to those which would be generated by venting the geothermal fluids under normal pressure. Larger particles which would also form will deposit rapidly, but these fine particles will remain suspended for long periods. At relative humidities above 75%, they will form fogs and, together with the ambient submicron sulfate particles, would reduce visibility. Such high humidities rarely occur in the Raft River Valley, except during winter inversion conditions. Also, as the filler particulate samples indicated, the ambient particle concentrations exceed those caused by well testing.

2.4.3 Meteorology

The 1977 summary of meteorological conditions, including ambient and dewpoint temperatures, wind speed and direction, precipitation, and solar radiation, will be completed by NOAA and project personnel in January 1978. A partial record of daily average, maximum, and minimum temperatures for 1977 is shown in Figure 7. A chart of average monthly temperatures and precipitation at the Malta and Strevell stations is shown in Figure 8, (prepared by the University of Utah Research Institute).

2.4.4 Socioeconomic

The socioeconomic study being conducted by the Battelle Human Affairs Research Center in Seattle has been completed. The final report, "Community Impact Assessment of a Diversified Geothermal Energy Project Proposed for the Raft River Valley, Idaho," by J. A. Goodnight, Battelle Human Affairs Research Center, Seattle, has been issued. The report concluded that because of the sparseness of settlement in the immediate area, the development and operation of either a 5 or 10-MW(e) thermal loop/power plant is expected to produce little impact on the local communities. The study also analyzed three levels of non-electric development:

TABLE VII

AVERAGE SUBMICRON PARTICLE CONCENTRATIONS
GENERATED FROM WATER FROM RRGE-2 AND RRGE-3
(number x $10^3 m^3$)

RRGE-2

Size Range	No/m^3 x 10^3	%/No.	ug/m^3	cc of H_2O used sampled	ug/cc
< 0.2	720,463	26.98	5.35		0.29
0.2-0.4	1,579,254	59.13	93.81		5.11
0.4-0.7	350,871	13.14	128.43		7.06
0.7-1.0	20,197	0.76	27.29		1.50
1.0-2.0	0	0	0		0
	2,670,785		254.88	10.2	14.0 ug/cc of H_2O

RRGE-3

Size Range	No/m^3 x 10^3	%/No.	ug/m^3	cc of H_2O used sampled	ug/cc
< 0.2	416,578	21.39	3.09		0.12
0.2-0.4	828,066	42.52	49.19		1.86
0.4-0.7	670,573	34.43	245.45		9.30
0.7-1.0	32,370	1.66	43.73		1.66
1.0-2.0	0	0	0		0
	1,947,587		341.46	26.4	13.0 ug/cc of H_2O

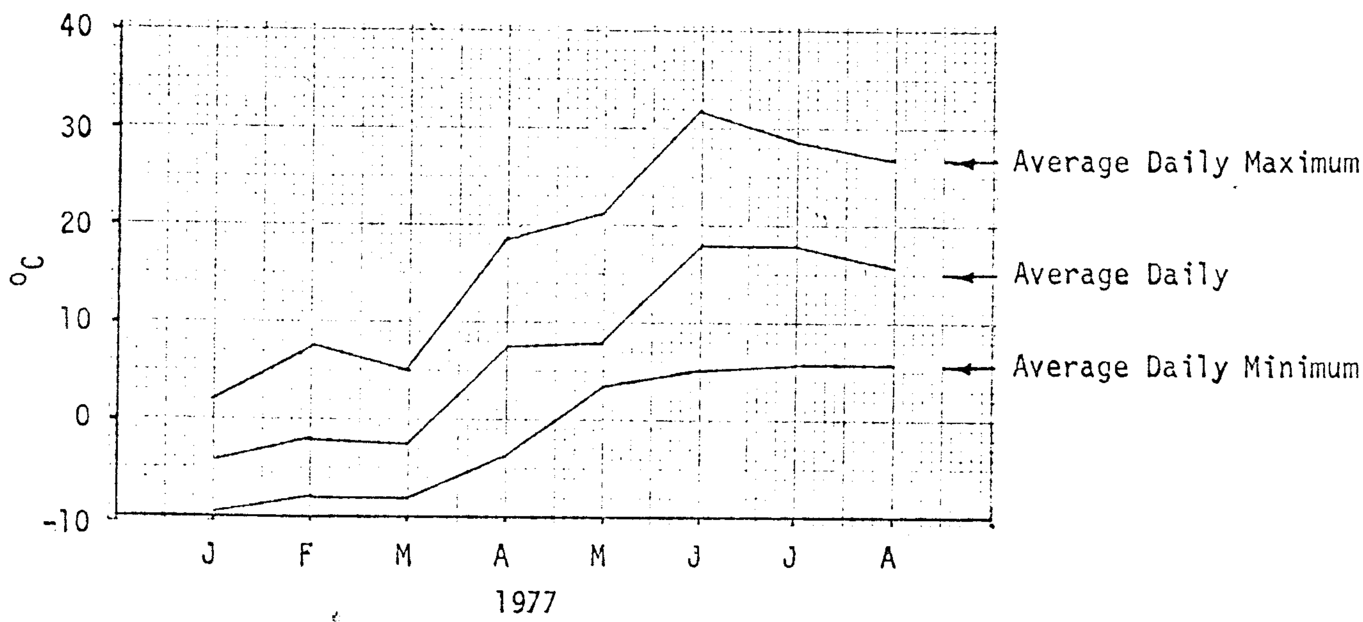
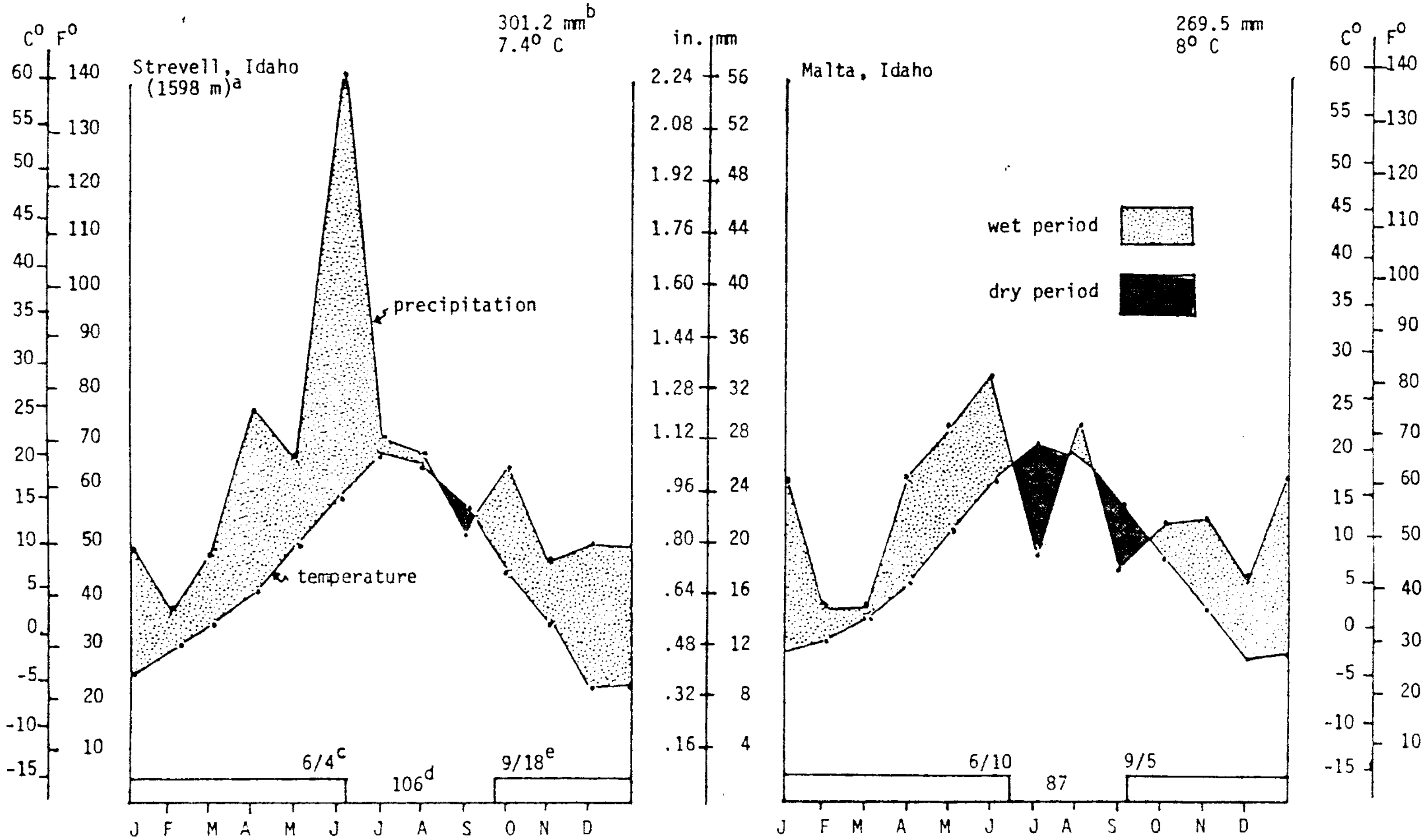


Fig. 7 Partial 1977 record of daily average, maximum, and minimum temperatures at Raft River



(aAltitude, bAverage precipitation and temperature, cLast frost of season, dNumber of frost free days, eFirst frost of season)

Fig. 8 Average monthly temperature and precipitation, Malta and Strevell

1. Most likely - 2 hectares (4.5 acres) of greenhousing and one fish farm producing and processing 113,000 kg of warm-water fish annually.

2. Possible - 8 hectares (18 acres) of greenhousing, one fish farm handling 226,000 kg of fish annually, one 10,000-head feedlot and associated manure processing facility, and 50 MW(e) power plant.

3. Maximum - 24 hectares (53 acres) of greenhousing, one fish farm with 454,000 kg per year production, one 20,000-head feedlot and associated manure-processing facility, one 50-MW(e) power plant, and one potato-processing plant producing 91,000 kg of hydrated flakes per day.

The study estimated that due to the limited availability of labor in the local area, approximately 60 non-local workers at the "possible" level and over 300 at the "maximum" level of activity would be required. Growth-management actions on the local and county level to minimize the impacts of population influx are detailed in the report.

2.4.5 Water Quality

Water-quality surveys are continuing. A program of weekly sampling of the geothermal wells and monthly sampling of the Raft River and nearby irrigation wells has been established. Routine analyses examine conductivity, pH, chloride, fluoride, silica, and total hardness. Patterns of water chemistry have been plotted for each of the geothermal wells and for shallow and intermediate-depth exploration and irrigation wells in the area. These patterns, shown in Figure 9, will be used as a graphical aid in classifying waters and in tracking the natural or induced interaction of "fresh" water and geothermal fluids.

A 30-m deep monitor well was drilled last spring near the northeast corner of the RRGE-3 reserve pit. A water-level recorder and a sampling pump were installed in the well to determine the effect on the shallow ground water of seepage from the reserve pit, during flow tests on RRGE-3. A series of samples was taken after the water level rose in both the monitor well and in the domestic well at RRGE-3. Analyses showed a slight increase in the total dissolved solids (TDS) in the domestic well (from 716 to 738 milligram/liter), but a corresponding decrease in the sodium content (from 420 to 390 milligram/liter). The total dissolved solids in the pit monitor well decreased from 4060 to 3740 milligram/liter. A corresponding decrease was seen in the other constituents measured. The TDS of the RRGE-3 water averaged 4600 milligram/liter during the test.

In June and September, the Idaho Department of Water Resources conducted water-quality surveys of irrigation wells and the Raft River. With one exception, no changes, other than natural fluctuations, have been seen in any of the wells since August 1975. In a well five miles

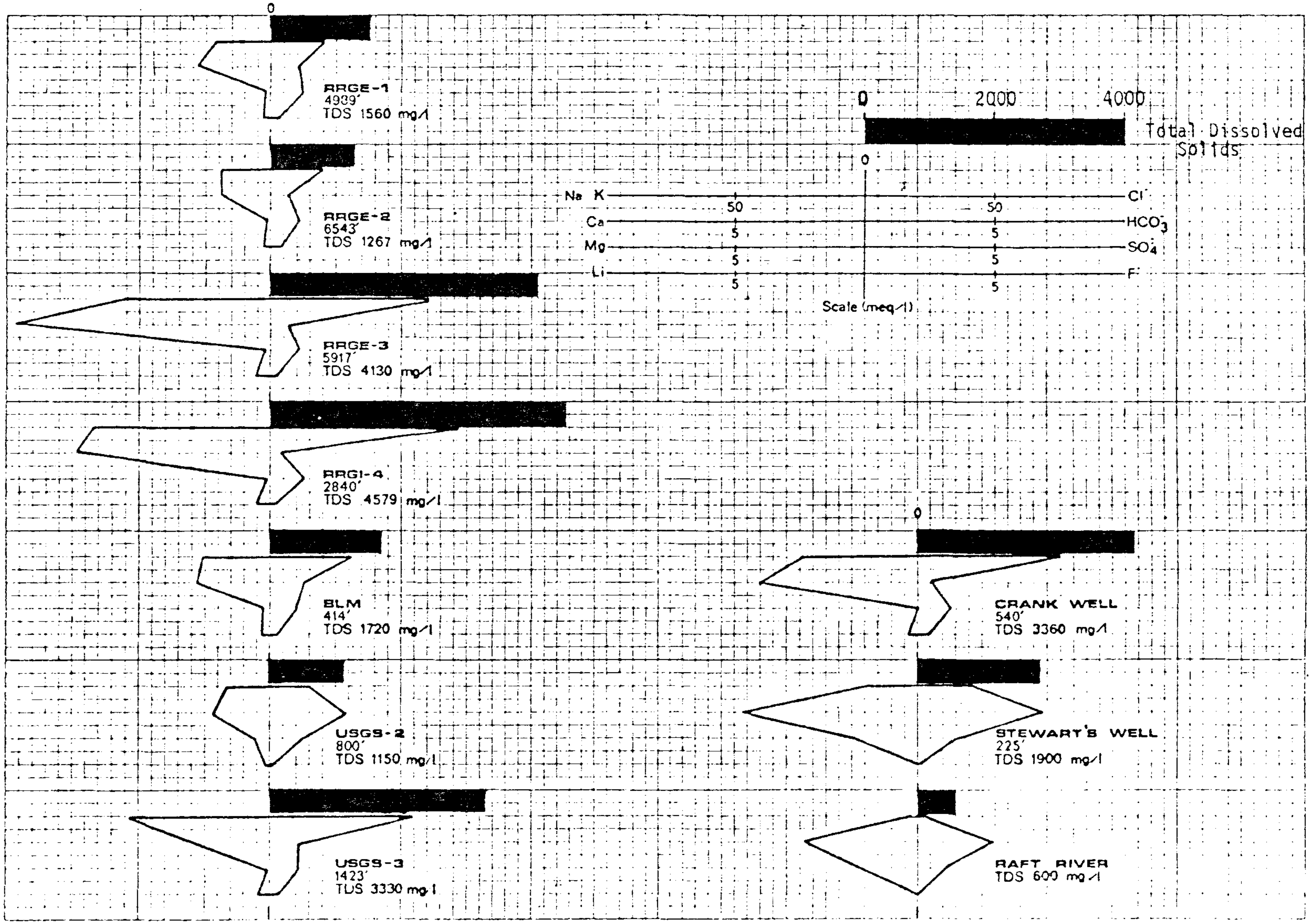


Fig. 9 Patterns of Raft River wells' water chemistry

to the northeast of RRGE-2, the total dissolved solids content increased from 2250 milligram/liter in August 1975 to 5300 milligram/liter in June 1977. By September 1977, it had dropped to 3500 milligram/liter. Most of the change in TDS resulted from increases in chloride, sulfate, and calcium. No similar changes were seen in nearby wells, nor could the changes be related to geothermal activity.