FUTURE WELL TESTING AND INJECTION AT THE EAST MESA FIELD

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The Bureau of Reclamation has established an ongoing program for the analysis and evaluation of the East Mesa Geothermal Field. This presentation will discuss the recent history of the field including testing methods and results. Future testing plans will also be discussed.

The East Mesa Field

Located from various geophysical studies including heat flow, gravity, seismic noise, and resistivity, the field lies on the east flank of the Salton trough. Mesa 6-1 was drilled to a depth of 2443 meters in 1972 at a common anomaly to the above geophysical parameters. The well was initially completed by a hanging slotted liner and later the uphole casing was perforated opposite permeable sand horizons. Produced fluid is of a sodium chloride type having a total dissolved solids (TDS) content of 26,300 mg/1 (unflashed wellhead sample).

Mesa 6-6 was drilled as a step-out well one-fourth mile west of Mesa 6-1. Completed to 1916 meters, produced fluid is of the sodium chloride type having a TDS content of 5000 mg/1 (unflashed wellhead sample).

In 1974 three additional wells were drilled, based on additional heat flow and seismic monitoring work. These wells are designated Mesa 5-1, Mesa 8-1, and Mesa 31-1. They flow a sodium chloride type water with a TDS content of about 2500 mg/1.

Table 1 describes the casing and completion program of each well. Well locations are shown in Figure 1.

Well Testing

Flow Testing. The portable flash tank and weir box has been most useful in obtaining flow information at East Mesa wells. A pipeline is connected directly to the flash tank from the well where fluid is flashed to atmospheric conditions. Steam from the well bore and flashoff evolve from the flash tank. Liquid passes into a weir box where level over a V-notch weir is measured. Clock-driven pressure, temperature, and level gauges monitor surface conditions, and calculations are made to determine total well flow. This technique was described by Mathias in 1975. Flow tests have been performed at all wells and represent conditions which exist at the wellhead during flows at various rates for a total flow period of several days. Low flow conditions are generally not at pressure, temperature or flow equilibrium due to the extended time required to heat surrounding uphole rock formations.

Pressure Testing. Downhole pressures have been measured using standard oil field type mechanical clock-driven recording instruments. In addition, a very sensitive downhole quartz pressure gauge was used to conduct interference tests in the East Mesa Field. This test was reported by Witherspoon, Narasimhan, and McEdwards in 1976. The results of mechanical gauge work and electronic precision gauge work were combined with flow data and used to evaluate and model the East Mesa Reservoir (TRW-Intercomp, 1976). The results of this work are presented elsewhere in these proceedings (Spivak and Rice, 1976).

Temperatures. Surface and downhole temperature have been measured both at shut-in and under flowing conditions. Standard oilfield type mechanical clock-driven recording instruments have been used for downhole measurements. A summary of bottomhole temperatures at shut-in equilibrium conditions is shown on Table 2.

Injection Operations

Mesa 5-1 has been used as an experimental injection well. It was located in an area of low heat flow and approximately two kilometers from the nearest microearthquake epicenter (Combs, 1974). The lower 305 meters were slotted opposite sand horizons having an average Saraband permeability of 69 millidarcies. During initial tests, water having a TDS of 50,000 mg/1 and a dissolved oxygen content of 6.9 mg/1 was injected. After 48 hours of pumping at a rate of 1000 m^3/day, water level reached the surface and pressure pumping began. At the end of ten days, surface pressure had risen to about 5.5 bars gauge. Average injection pumping was then 400 m^3/day. Intermittent pumping was then begun, as required pressure was above pumping equipment capacity on hand. Surface pressure varied between 0 and 14 bars while pumping intermittently at a wide range of rates. A summary of injection activities from February 28 through April 2, 1975 is tabulated on Table 3.

An average of 0.0923 grams per liter suspended solids was measured in the injection fluid. A sample of the fluid filtrate was analyzed by X-ray diffraction techniques. The primary constituents were found to be quartz, clay-sized particles, and other material that would be wind blown into a pond in a desert area. From the above concentration value, a total weight of 1030 kilograms of solid material is calculated to have been pumped down the well.

Piping at the test site was revised so that fluid blowdown from geothermal operations would be transported directly into the injection system with minimal contact to air and no contact with the brine holding pond. As high corrosion was noted in the lower portion of the downhole wireline equipment, it was suspected that corrosion damage to the casing may have resulted. A Schlumberger casing thickness log was run in December of 1975 and no damage was detected.

A high pressure pump of capacity to pump up to 138 bars gauge pressure at 1088 m^3/day was added to the wellhead. Fluid was injected using this pumping arrangement from January 14, 1976 to January 28, 1976. A summary of wellhead pressures is shown on Figure 2. It was noted that at a pressure of near 85 bars gauge, wellhead pressure decreased. Sufficient pumping capacity was not available to increase the volume of fluid injected to maintain the 85 bars gauge wellhead pressure.

In May, 1976, the injection well was acid treated with 38 m^3 of 15% HCl, 38 m^3 of mud acid, and 19 m^3 of 5% HCl. Short term pumping concluded that the treatment had resulted in improved acceptance characteristics of the well.

Future Testing

General. A testing program involving all operators at the East Mesa Field is scheduled for early 1977. The testing program will search two main areas. First, a flow profile test for each well connected into a disposal system (Mesa 8-1, 6-1, and 6-2) will be run to ascertain the latest characteristics of the wells at low flow rates. As these wells will be used to supply the ERDA test pad at the test site, it is important to know each well characteristic at the range of flows to be utilized. The second parts of tests involves interference tests. The details of this test program are outlined below. This testing program and others in the future will involve other equipment and programs at the site. These include injection, seismic monitoring, chemical, and other geophysical monitoring. These will also be discussed in detail.

Interference Testing. The interference test will be of a duration of at least 30 days. Precision quartz pressure gauges will be placed in select wells operated by Republic, Magma Power Co., and the Bureau. The Bureau's production well Mesa 6-2 will be operated at a low flow rate (about 800 m^3/day). Magma Power Company will provide a continuously recording surface readout downhole capillary type pressure gauge to be placed in this well. Fluid will be injected at well Mesa 5-1. The effects of pressure drawdowns and buildups in the field will be analyzed and used to refine the already existing model developed by TRW and Intercomp.

Precision pressure gauges, operating personnel and analysis of results will be supplied by Lawrence Berkeley Laboratory.

Injection Equipment. Fluid conveyed to Mesa 5-1 wellsite will be moved downhole by a high speed centrifugal pump. Bypass equipment has been installed at the pump to maintain a steady and optimum flow of about 1088 m^3/day at 60 bars pressure through the pump while allowing less fluid to be injected. The Mesa 5-1 wellhead is fully instrumented to indicate wellhead pressure, temperature, flowrate, and totalized flow. This apparatus is shown on Figures 3 and 4.

Seismic Monitoring. The Bureau six-station seismic monitoring array is situated within an area of about 6 km radius of the test site office. Each station is comprised of three component seismometers of which signals are telemetered by FM radio link to the Bureau office. The data is recorded on magnetic tape at that location. Correlation between seismic activity and reservoir parameters have been observed in the past. In one case, (Witherspoon, Narasimhan, McEdwards, 1976), 14 local seismic events in a time period of less than one hour corresponded directly to a rise in pressure in well Mesa 8-1 but not in Mesa 6-1. These events were located two to four miles east and northeast of Mesa 8-1. It is possible that a reservoir boundary prevented a pressure signal from being transmitted to Mesa 6-1. Differing frequency content and anomalous travel time delays from events occurring outside the field have led us to believe that there exists an anomalous region in the East Mesa Field (Combs, 1975). A set of calibration blasts was arranged to learn more about this phenomena; the results of this work are not yet completed.

Seismicity in the Imperial Valley has been seen to affect the chemical content of wells during production. The most remarkable change has been the association of area seismic activity with increases in wellhead CO_2 at Mesa 6-2 during production. Additional seismic recording equipment is being installed to help further define this observation.

REFERENCES

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2. Combs, J., 1975; Microearthquake Studies Before and During Fluid Withdrawal and Reinjection Test; Mesa Geothermal Field, Imperial County, California, Report prepared for Bureau of Reclamation, Lower Colorado Regional Office under Contract Number 14-06-300-2563.

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6. Witherspoon, P. A.; Narasimhan, T. N.; and McEdwards, D. G., 1976; Results of Interference Tests from Two Geothermal Reservoirs: Lawrence Berkeley Laboratory, Soc. Petroleum Engineers of AIME 51st Fall Meeting, New Orleans.

Table 1

Casing and Completion Records,
Geothermal Resource Investigations,
Imperial Valley, California

Mesa well number	Casing outside diameter (in.)	Depth interval (m)	Slotted interval (m)	Perforated interval (m)	Average Saraband sand permeability (md)
6-1	20	0-116			
	13 3/8	0-763			
	9 5/8	0-2223		2075-2179/1868-2075	230
	7	2213-2443	2238-2433		1.5
6-2	20	0-19			
	11 3/4	0-301			
	7 5/8	0-1816	1663-1816	1392-1662	70
5-1	20	0-18			
	13 3/8	0-312			
	7 5/8	0-1830	1525-1830		69
8-1	20	0-18			
	13 3/8	0-304			
	7 5/8	0-1829	1508-1829		39
31-1	20	0-18			
	13 3/8	0-309			
	7 5/8	0-1882	1652-1882		62

Table 2

Bottom-hole shut-in temperatures,
Geothermal Resource Investigations,
Imperial Valley, California

Mesa Well Number	Depth Measured (m)	Bottom-hole temperature (^{o}C)
6-1	2442	204
6-2	1816	188
5-1	1830	157
8-1	1830	179
31-1	1882	154

Table 3

Injection Schedule, Mesa 5-1,
February 28-April 2-1975

Date 1975	Time	Operation	Average flow rate (m^3/day)	Cumulative quantity flowed (m^3)
Feb. 28	1015	Begin Injection	1 090	0
Mar. 11	1730	Stop Injection	398	6 968
Mar. 11	1020	Begin Injection	398	-
Mar. 12	1745	Stop Injection	125	7 222
Mar. 12	1840	Begin Injection with Booster pump	1 281	-
	1330	Stop Injection	600	7 416
	1450	Begin Injection	441	-
	2100	Stop Injection	578	7 490
Mar. 13	0915	Begin injection	1 128	-
		Average flow during injection	273	
Mar. 25	1525	Stop Injection	343	11 184
Apr. 2	0955	Begin injecting shallow well water	300	-
Apr. 2	1300	Stop Injection	300	11 441

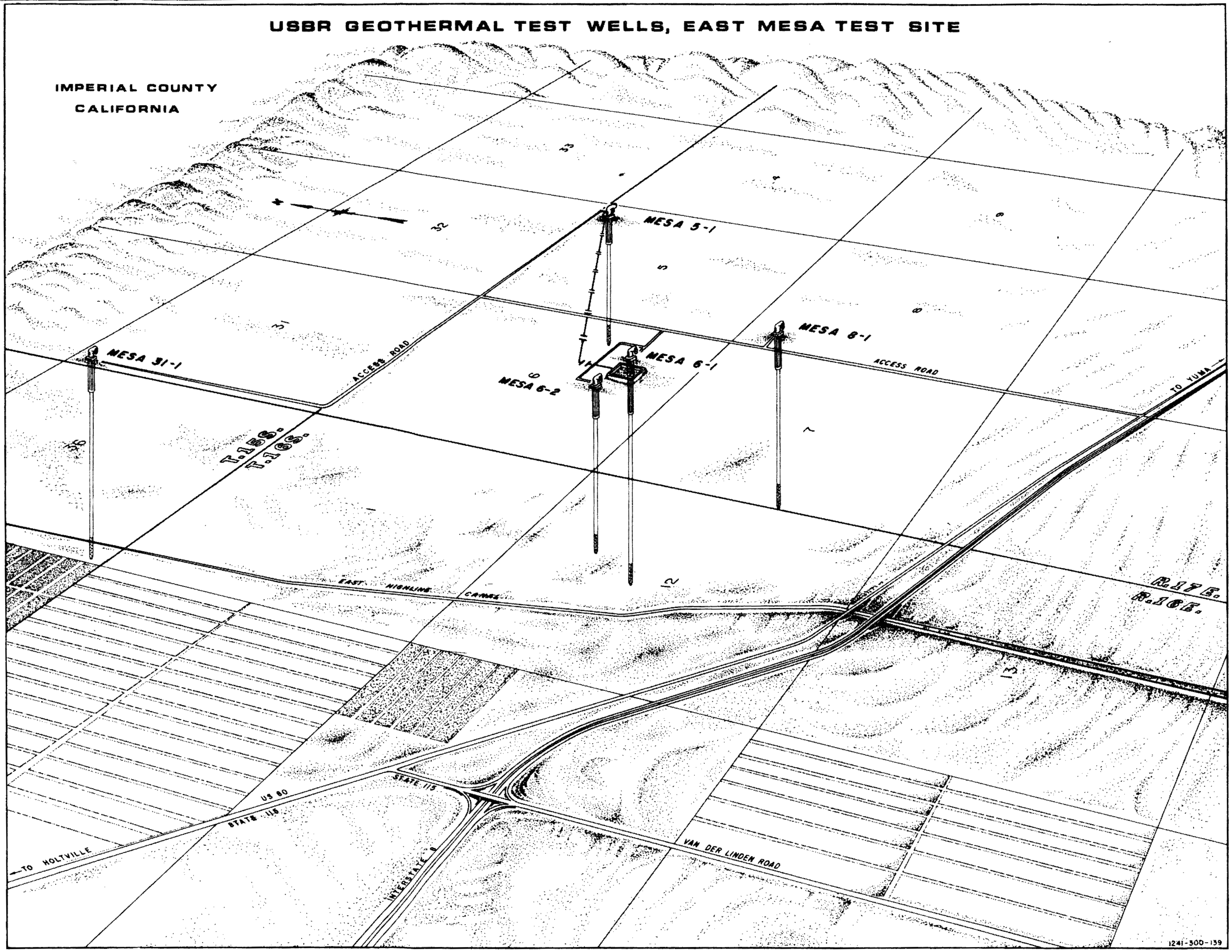

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Figure 1. Locations of U.S. Bureau of Reclamation Geothermal Test Wells, East Mesa Test Site.

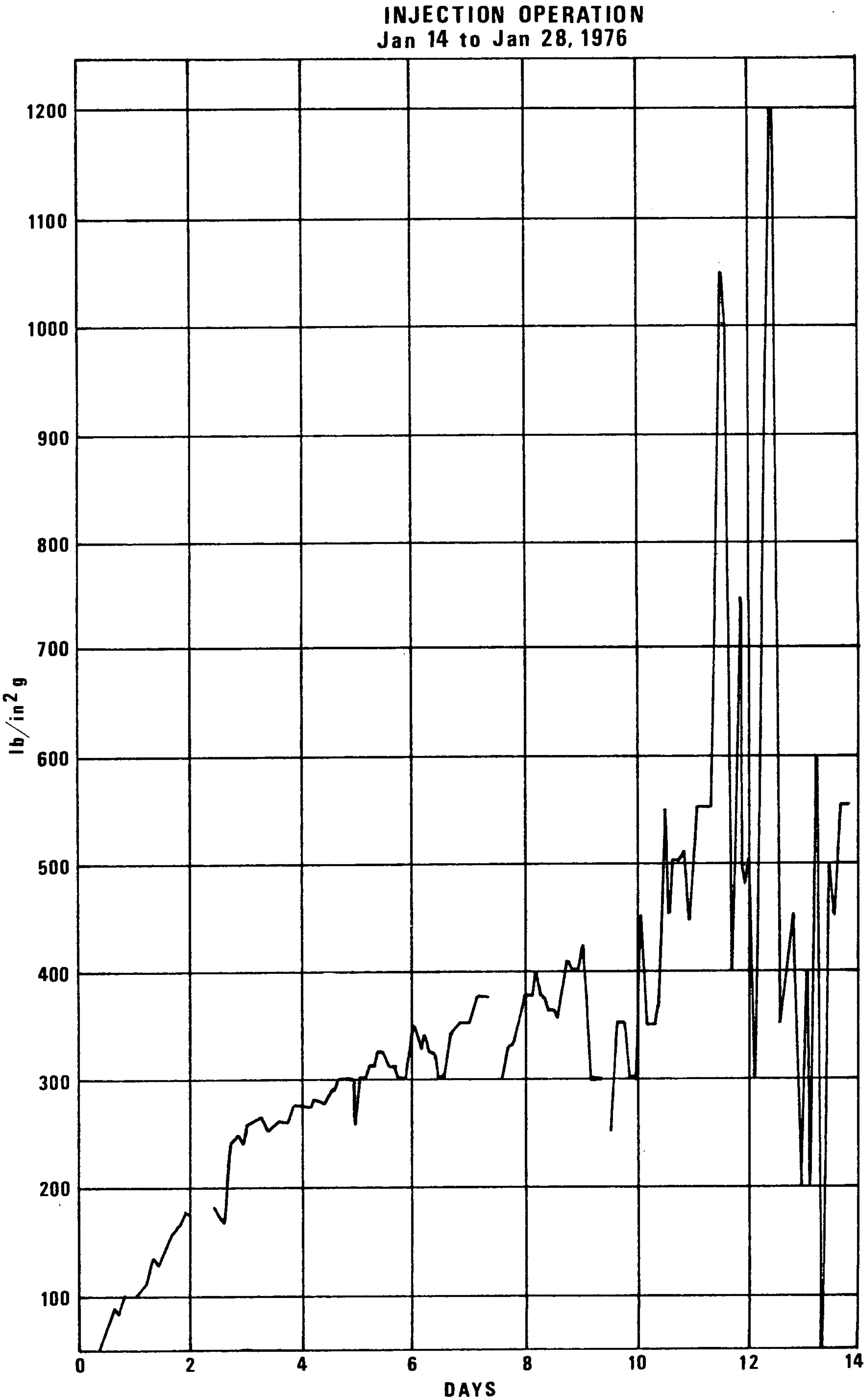

Figure 2. Summary of Well-head Pressures, Mesa 5-1 Injection, January 14 to January 28, 1976.

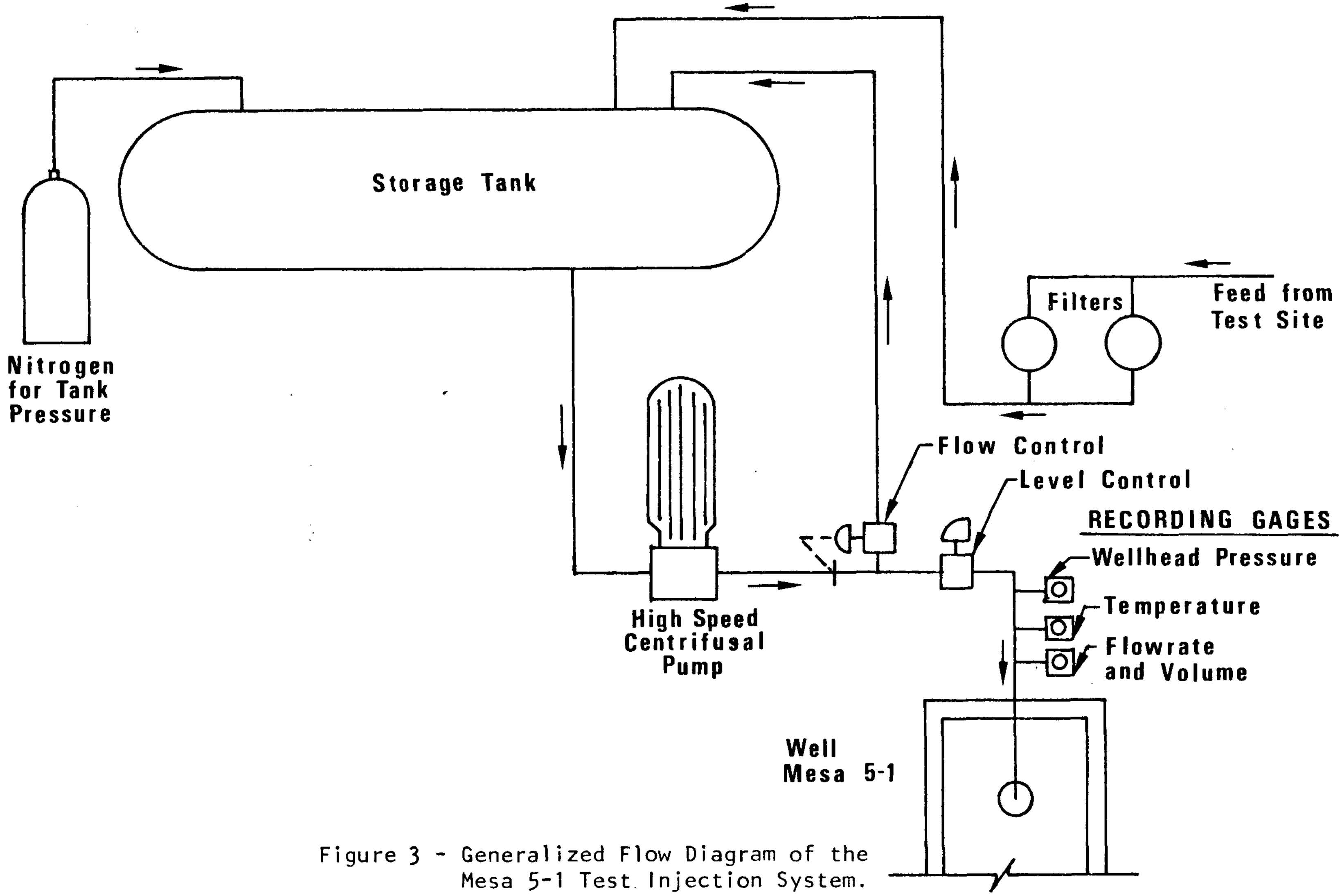

Figure 3 - Generalized Flow Diagram of the Mesa 5-1 Test Injection System.

Test Injection System

Fig. 4. Mesa 5-1 Test Injection System during Fabrication. Well Mesa 5-1 is out of view to the right.