Aquifer-Test Report for J-12 WW, Area 25, Nevada Test Site

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INTRODUCTION

The U.S. Geological Survey (USGS) proposed to the U.S. Department of Energy (DOE) that an aquifer test be conducted using wells J-12 WW, J-13 WW, and JF-3 (fig. 1). These wells produce water from the same welded-tuff aquifer. The transmissivity of the welded-tuff aquifer was estimated to constrain hydraulic parameters used in ground-water models at the Nevada Test Site. The aquifer test was analyzed with the Theis (1935) solution.

TEST DESCRIPTION

The aquifer test started when well J-12 WW began pumping at 14:33 Pacific Standard Time on January 5, 2004. Water levels in well J-12 WW had recovered for about 144 hours prior to this test. An average of 780 gallons per minute was discharged from J-12 WW for approximately 24 hours. No water was discharged from nearby production well J-13 WW during this time period (fig.1). Water levels were monitored at one-minute intervals in J-12 WW and at 15 minute intervals in wells
J-13 WW and JF-3 for the duration of the test.

Water level change in wells J-12 WW, J-13 WW and JF-3 were measured simultaneously from 12/15/03 to 01/28/04 with pressure transducers. The manufacturer provided accuracy of these transducers was ±0.03 ft in J-12 WW, ±0.014 ft in J-13 WW, and ±0.007 ft in JF-3. The transducers were calibrated under laboratory and field conditions. Water temperature and barometric pressure also were measured at each well site. Discharge from well J-12 WW was measured to within 10 gallons per minute (R.J. La Camera, written communication, 2003).

AQUIFER TEST SITE

Wells J-12 WW, J-13 WW, and JF-3 are located at 36°45´54´´N. 116 °23´24´´W., 36°48´29´´N. 116 °23´40´´ W., and 36°45´28´´N. 116 ° 23´22´´W., respectively, in Area 25 of the Nevada Test Site (fig. 1). J-13 WW is approximately 3 miles north of J-12 WW and J-12 WW is approximately 0.5 miles north of JF-3.

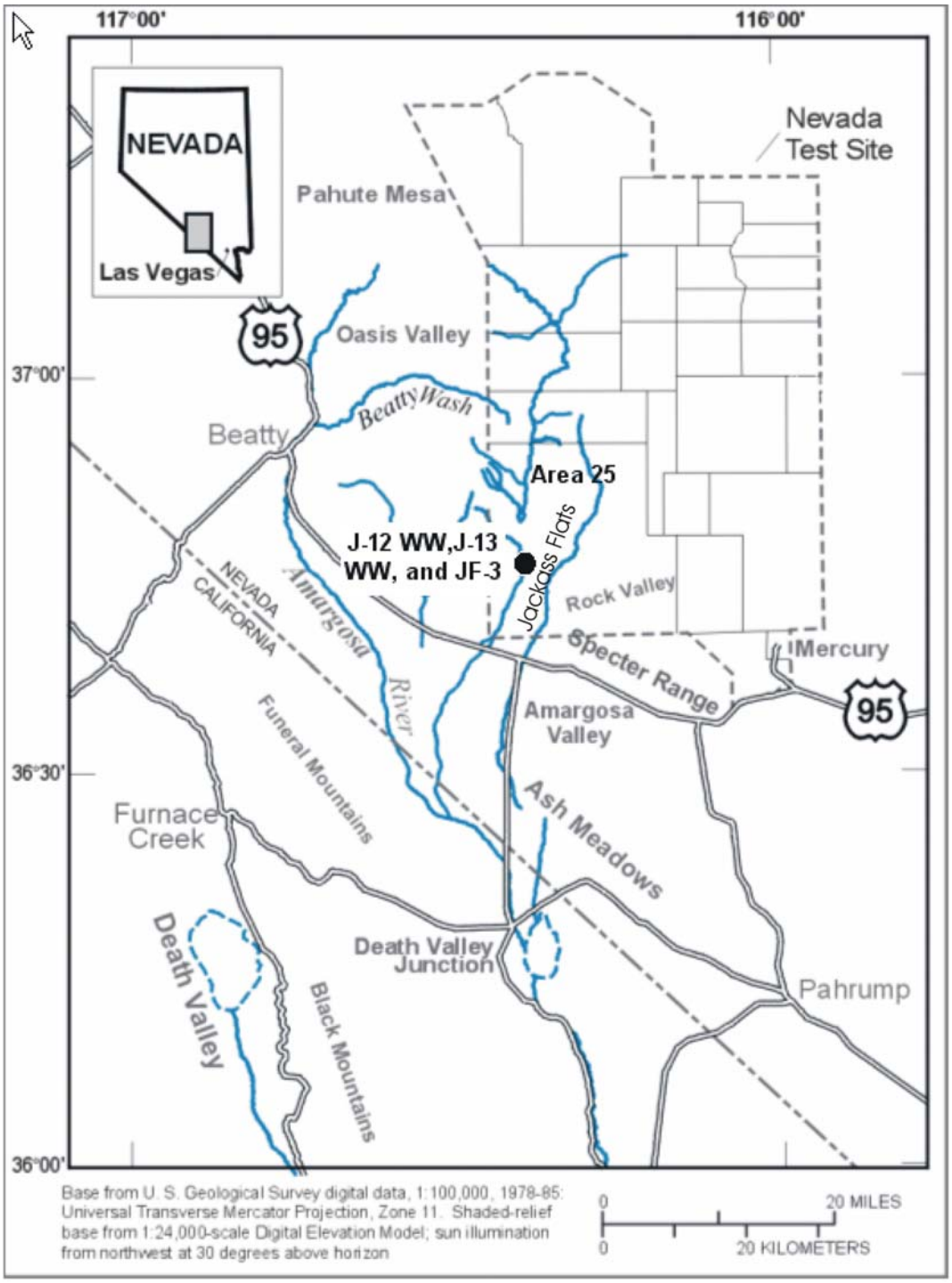

Figure 1. Location of wells J-12 WW, J-13 WW, and JF-3 on the Nevada Test Site.

CONSTRUCTION

Wells J-12 WW and J-13 WW were drilled in the Jackass Flats area as water-supply wells. Well JF-3 was drilled for monitoring water levels. Wells J-12 WW, J-13 WW, and JF-3 were completed or last recompleted, respectively, in August 1968, January 1963, and January 1992. Figure 2 provides detailed information about well construction (Thordarson and others, 1967, p.15; Claassen, 1973, p. 24; Thordarson, 1983, pgs. 6-7; Arteaga and others, 1991, p. 22; Plume and La Camera, 1996, p. 6).

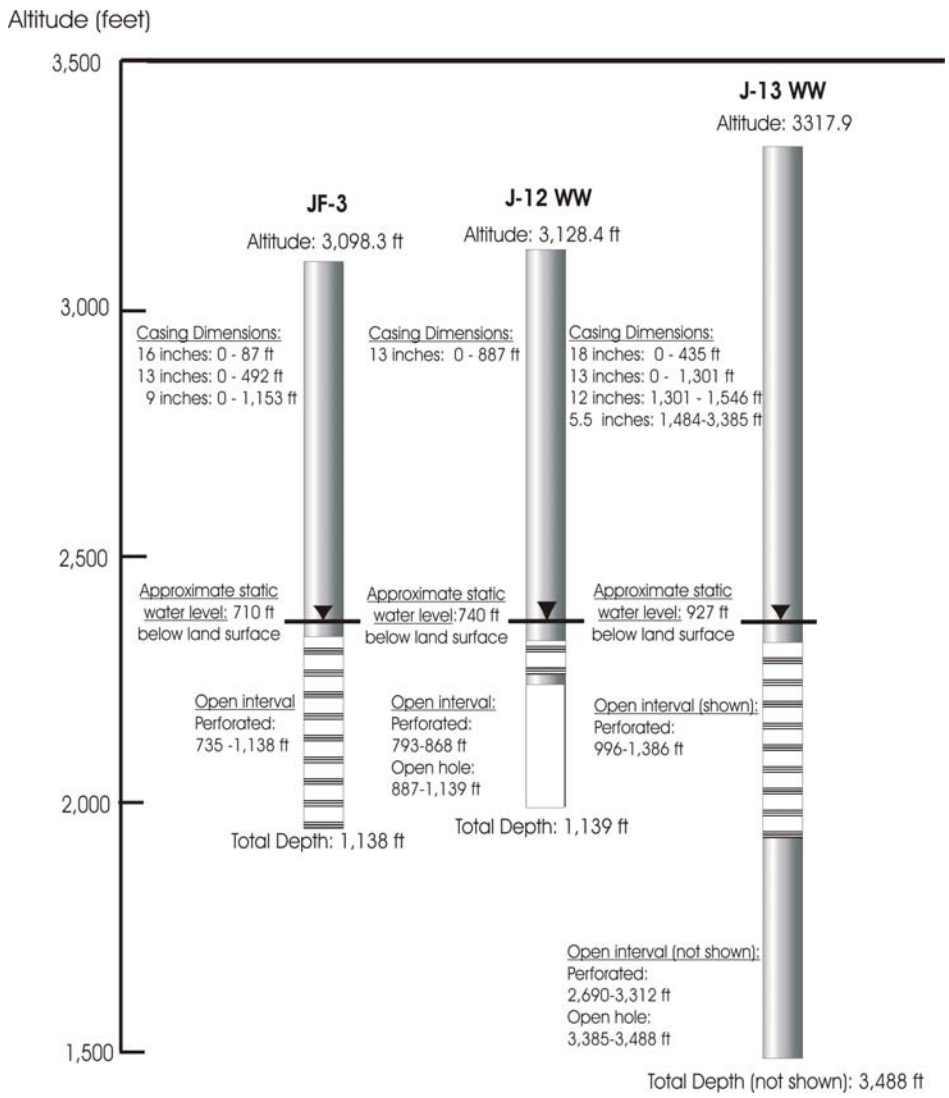

Figure 2. Construction of wells J-12 WW, J-13 WW, and JF-3. Casing dimensions, open interval, total depth, and static water level are reported in feet below land surface.

HYDROGEOLOGIC CHARACTERISTICS

Wells J-12 WW, J-13 WW, and JF-3 were completed in Tertiary volcanic rocks (fig. 3). In Jackass Flats, valley-fill deposits, undifferentiated Tertiary volcanic rocks, and the top of the Topopah Spring Tuff make up the upper unsaturated unit. The Topopah Spring Tuff is the main source of water to wells J-12 WW, J-13 WW and JF-3 with a saturated thickness of 400-600 ft. Confining Tertiary volcanic rocks underlie the Topopah Spring Tuff and separate this aquifer from Paleozoic carbonate rock (Fenelon and Moreo, 2002, p. 54).

The Topopah Spring Tuff aquifer is a moderate to densely welded ash-flow tuff. Zones of lithophysae and fracturing in the upper to middle part of the aquifer yield the most water. Total thickness of the Topopah Spring Tuff is at least 519 ft at J-12 WW, 795 ft at J-13 WW, and 560 ft at JF-3 (Thordarson, 1983, p. 11; Plume and La Camera, 1996, p. 11). Nearby water levels imply an upward ground-water gradient from the Paleozoic carbonate rock-aquifer to the Topopah Spring Tuff aquifer (Fenelon and Moreo, 2002, p. 54).

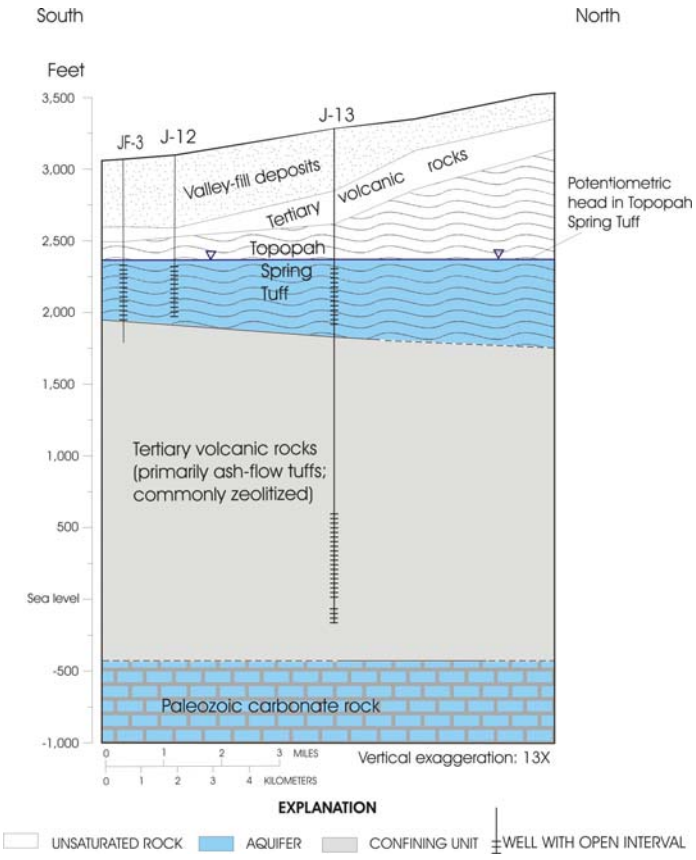

Figure 3. Well construction and hydrogeologic units at J-12 WW, J-13 WW and JF-3 (modified from Fenelon and Moreo, 2002, p. 55).

DRAWDOWN ESTIMATION

Drawdowns in wells J-12 WW and JF-3 were estimated by subtracting a surrogate water level from the measured water level (figs. 4 and 5). Surrogate water levels are created to simulate water-level changes in wells J-12 WW and JF-3 caused by non-pumping stresses. These stresses include barometric changes, earth tides, and other small stresses that are observed in other background wells unaffected by pumping. The amplitude and phase of each non-pumping stress time series were estimated to minimize the difference between surrogate and pre-pumping measured water levels. Earth tides were computed from a finite-series Fourier regression of sines and cosines using the precise frequencies of the 6 principal earth tides (Galloway and Rojstaczer, 1989). Tracer Well 3 (N 36°32’ 13”, W116°13’38”) and USGS-MX Delamar well (N 37°26’39”, W 114°52’09”) which were completed, respectively, in carbonate rock and alluvium, were used as background wells. Water levels in Tracer Well 3 had the most influence in determining the surrogate water level for wells J-12 WW and JF-3.

Measurable drawdowns were observed only in the pumping well J-12 WW (fig. 4). More than 95 percent of the 7.3 ft of drawdown was caused by convergence of flow to the few fractures that intersect the well and entry losses to the pumping well. Additional drawdown between 0.25 and 24 hours after pumping started was less than 0.3 ft. Measurable drawdowns were not observed in well JF-3 and corrected water levels suggest a small drawdown of about 0.01 ft (fig. 5). The minimum drawdown that could have been detected in well JF-3 was 0.01 ft. Drawdowns in well J-13 WW were not observed or estimated based on surrogate well responses.

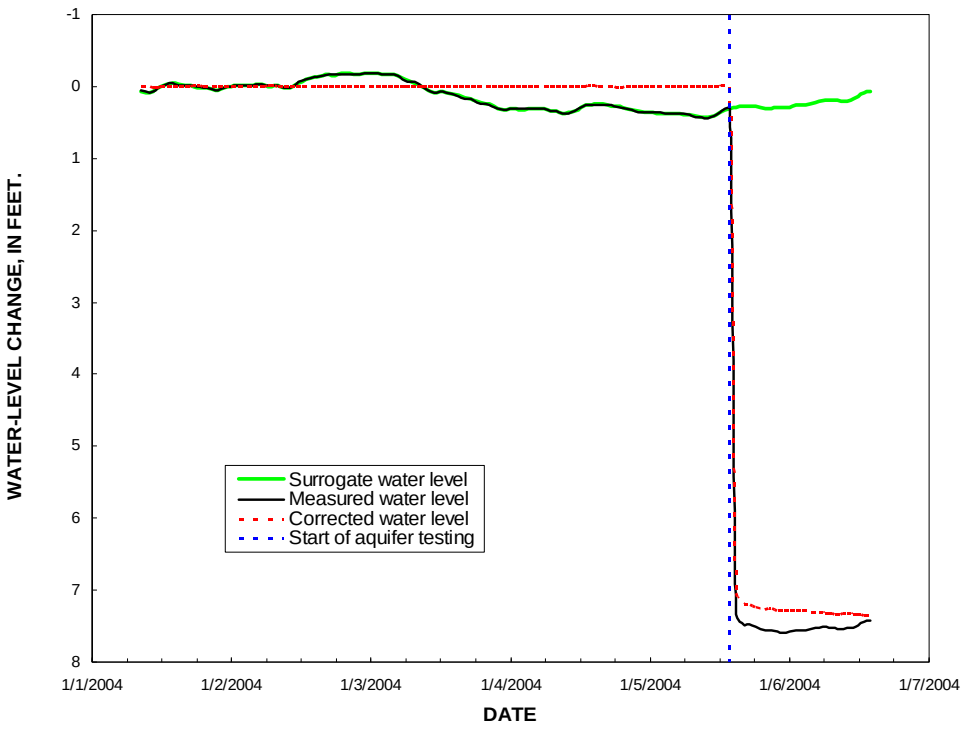

Figure 4. Surrogate, measured, and corrected water-level changes in well J-12 WW between 1/1/2004 and 1/07/2004.

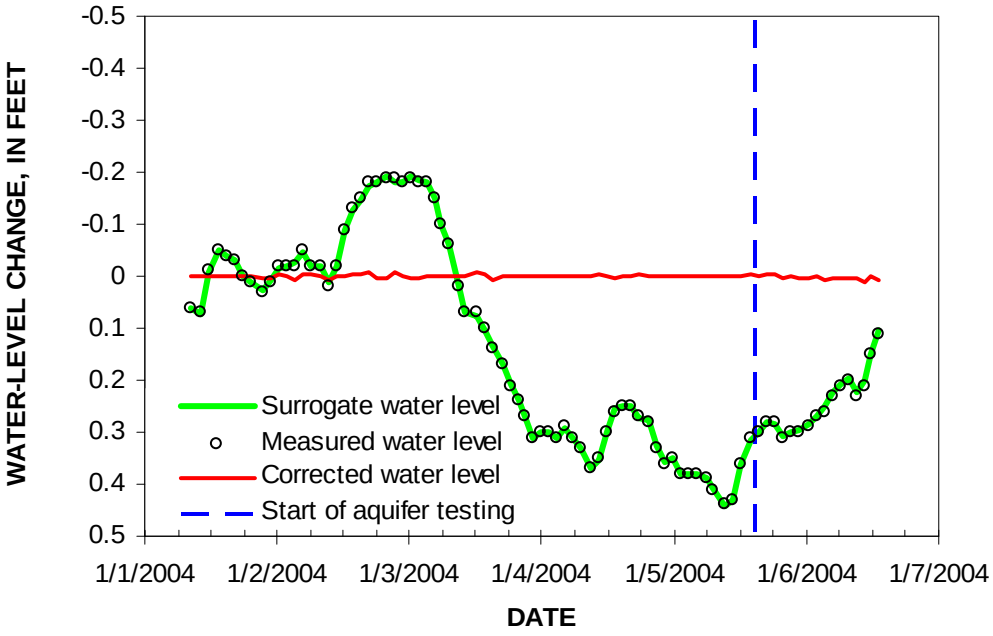

Figure 5. Surrogate, measured, and corrected water-level changes in well JF-3 WW between 1/1/2004 and 1/07/2004.

AQUIFER TEST ANALYSIS

The aquifer test was analyzed with the Theis solution. The pumping well penetrated more than 90 percent of the 420 ft of saturated thickness. Vertical hydraulic conductivity was assumed to equal horizontal hydraulic conductivity because fractures were abundant and geometrically complex (Laczniack, 1996). Simulated drawdowns at the water table and base of the welded tuff aquifer based on a theoretical solution to unconfined flow (Barlow and Moench, 1999) differed no more than 0.01 ft for a vertical-to-horizontal anisotropy of 0.1. These slight drawdown differences suggest that a Theis approximation is adequate because drainage from the water table cannot be differentiated from rock and water compressibility. The lack vertical drawdown differences thwart estimating specific storage and vertical anisotropy even if the aquifer is simulated with an unconfined solution.

Simulated and measured drawdowns from about 0.25 hour after the start of the aquifer test were compared. This was done to minimize the effects of well-entry head losses on the analysis of aquifer hydraulic properties. The initial 7 ft of drawdown in well J-12 WW was attributed to entry losses which changed little 0.25 hour after the test began. Subsequent declines were attributed to aquifer response.

Hydraulic properties were estimated by simultaneously minimizing the sum-of-squares differences between simulated and measured drawdowns in wells J-12WW and JF-3. Simulated drawdowns matched measured drawdowns within about 0.01 ft (fig. 6). Recovery data was not used because the uncertainty of drawdown estimates was greater during this phase of the test than during the pumping phase of the test.

Aquifer transmissivity was estimated to be 200,000 ft^2/d. This value is similar to a previous estimate of 150,000 ft^2/d from a single-well aquifer test in JF-3 (Plume and La Camera, 1996, p. 1). Transmissivities near wells J-12 WW and JF-3 are much greater than a transmissivity estimate of 1,300 ft^2/d from a single-well aquifer test in well J-13 (Thordarson, 1983, p. 27). Large differences in transmissivity over distances of less than 5 miles are possible in welded tuffs (Plume and La Camera, 1996, p. 17).

Specific yield was assumed equivalent to storage coefficient and estimated to be greater than 0.04. A minimum value of specific yield of 0.04 was estimated by assuming that a 0.01-ft drawdown was detected in well JF-3 during the last hours of the test. Slight drawdowns might have occurred in well JF-3 but were near the level of detection (fig. 6). The minimum specific yield would be 0.03 if the maximum undetected drawdown was 0.02 ft.

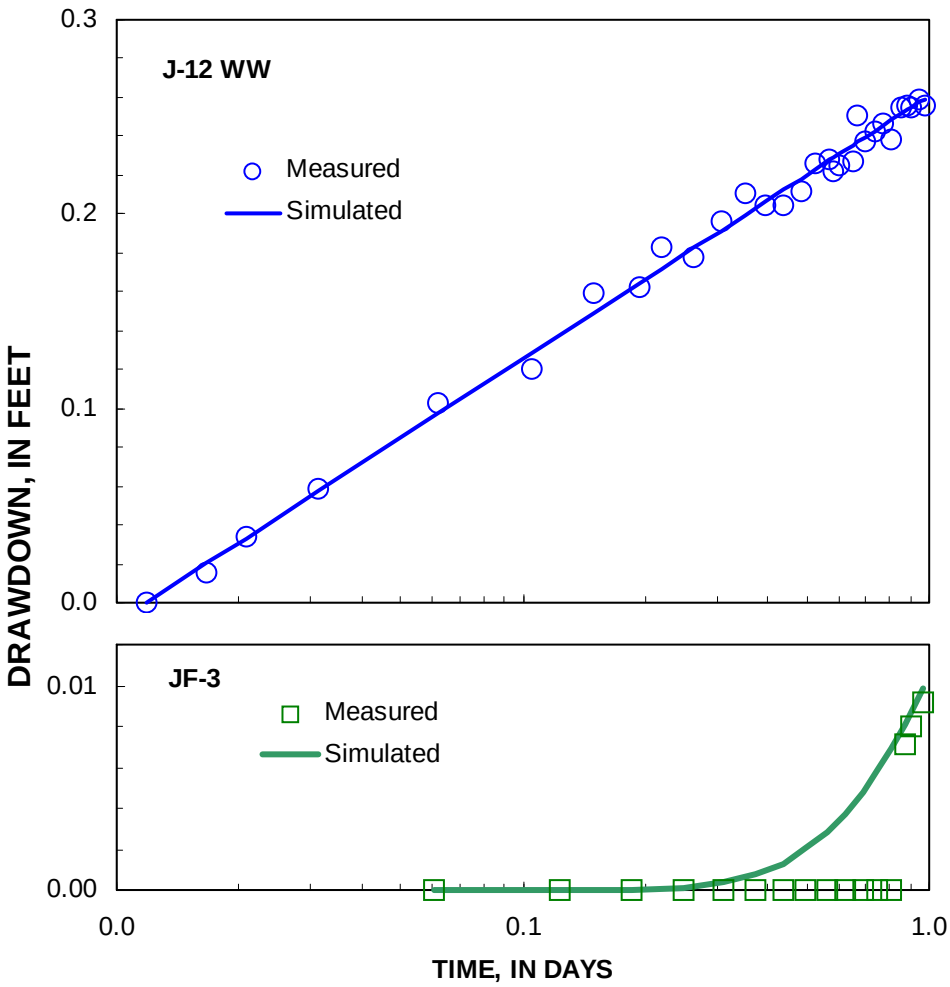

Figure 6. Measured and simulated drawdowns in wells J-12WW and JF-3 during aquifer testing, January 5-6, 2004.

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APPENDIX A-DRAWDOWN RECORD for well J-12 WW

	DRAWDOWN, IN FEET	
DATE-TIME	MEASURED	CORRECTED
1/5/2004 14:33	0.00	0.00
1/5/2004 14:41	7.33	7.04
1/5/2004 14:50	7.37	7.07
1/5/2004 14:57	7.38	7.09
1/5/2004 15:03	7.40	7.11
1/5/2004 15:18	7.43	7.13
1/5/2004 16:02	7.47	7.18
1/5/2004 17:05	7.47	7.20
1/5/2004 18:08	7.51	7.23
1/5/2004 19:11	7.53	7.24
1/5/2004 19:50	7.57	7.26
1/5/2004 20:53	7.56	7.25
1/5/2004 21:56	7.58	7.27
1/5/2004 22:59	7.58	7.29
1/6/2004 0:02	7.57	7.28
1/6/2004 1:05	7.55	7.28
1/6/2004 2:08	7.56	7.29
1/6/2004 3:11	7.56	7.30
1/6/2004 4:14	7.55	7.30
1/6/2004 4:32	7.53	7.30
1/6/2004 5:03	7.52	7.30
1/6/2004 6:06	7.51	7.30
1/6/2004 6:36	7.53	7.33
1/6/2004 7:14	7.51	7.31
1/6/2004 8:17	7.52	7.32
1/6/2004 8:57	7.54	7.32
1/6/2004 10:00	7.53	7.31
1/6/2004 11:03	7.52	7.33
1/6/2004 11:45	7.49	7.33
1/6/2004 12:17	7.46	7.33
1/6/2004 13:18	7.43	7.34
1/6/2004 13:56	7.43	7.34