DATA SUMMARY FOR CLOSED-LOOP PUMPING AND INJECTION TEST LIGHTNING DOCK GEOTHERMAL PROJECT HIDALGO COUNTY, NEW MEXICO JANUARY 16 – FEBRUARY 3, 2012

by

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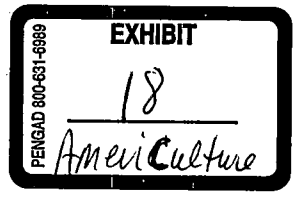

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INTRODUCTION

This summary provides, in the form of basic-data graphs, the results of a partial closed-loop test involving four geothermal wells (two tested as production wells and two tested as injection wells), and 12 observation wells. The locations of pumped wells, injection wells, and observation wells included in the test are shown on Figure 1. Water-level measurements began on January 14, 2012, and continued into January 31. Pumping from Well 53-7 began on January 16, and from Well 45-7 on January 18. Pumping and injection ceased on January 31. Recovery was measured in Well 45-7 until February 3.

Data for the test were collected by personnel of Tecton Geologic, except for hand measurements in some observation wells taken for a part of the test period by Chance Coats of John Shomaker & Associates, Inc. (JSAI).

WELLS

Wells included in the pumping and injection test are described in Table 1. Both the total depth of Well 53-7, and the approximate actual depth below ground level at the end of the sidetracked hole, are given in the table.

Table 1. Wells included in partial closed-loop pumping test, Lightning Dock Geothermal Project, January 16 through February 3, 2012. Well locations (all within Sec. 7, T. 25 S., R. 19 W.) are shown on Figure 1.

well	NMOSE Well No.	total depth, ft	casing diameter, in.	temperature, °F
45-7 (pumped well)	A-758 POD 3	2,900	13-3/8	317
53-7 (pumped well)	A-758-POD4	4,441 (2,360*)	13-3/8	
55-7 (injection well)	A0758 POD1	2,349	16	307
State No. 7 (injection well)	A-0094	699	8	185
State No. 3	A-0095?			
McCants West, 12-7	A-0603	994	6	141
McCants East, 52-7	A-0608	2,209	6	136
A-125	A-0125	shallow	6	
G-6-W, BLM 10	A-0122	151	10	207
Little House	A-0117	shallow	6-1/2	118
Twenty Acres, 36-7	A-0605	1,000	8	92
G-2-SE	A-0105	400	10	207
A-131	A-0131	shallow	11	
A-132, BLM 23	A-0132	85	12	
A-133	A-0133	shallow	6-1/2	
G-3-S	A-0097	130	8	207

NMOSE - New Mexico Office of the State Engineer
* approximate actual depth below ground level at the end of the sidetracked hole

BASIC-DATA GRAPHS

Pumping and Injection Rates

The general goal of the test was to maintain equilibrium between the pumping rate and the rate of re-injection in order to simulate power-plant operating conditions. Water was pumped from geothermal production Wells 45-7 and 53-7, at the rates shown on Figures 2 and 4 respectively, and re-injected into geothermal Well 55-7 at the rates indicated on Figure 5. Well 45-7 was pumped at rates from about 870 gallons per minute (gpm) to 1,300 gpm, and Well 53-7 at rates generally between about 430 and 600 gpm. Of the total pumped, 1,000 to 1,300 gpm was re-injected through Well 55-7. Well 53-7 was pumped with an air-lift, using

compressed air piped into the well to lift water to the surface. There was no conventional lineshaft or submersible pump in Well 53-7.

The water pumped from the two geothermal wells was routed to a holding pond, and then pumped to the injection well. Part of the pumped water was lost as it flashed to steam in the holding pond.

During the latter part of the test period, in addition to the geothermal-project wells, water was pumped from a shallow off-site well and injected into the State 7 well, also a geothermal well. Injection was at the rates shown on Figure 7, generally in the range 200 to 300 gpm.

Pumping from Well 45-7 was almost continuous, except for a period of about 1 day on January 24 and 25, but operation of Well 53-7 was interrupted frequently, as indicated by Figure 4. The flow balance during the first 8 days of pumping, before water from an off-site well began to be injected into the State 7 well, generally showed that when both wells were pumping, the pumping exceeded the injection rate by 300 to 400 gpm, the amount lost from the holding pond as steam. During the periods when Well 53-7 was not pumping, there was an excess of re-injection of 100 to 200 gpm because water previously pumped from Well 53-7 and stored in the holding pond was being re-injected in addition to the amount available from Well 45-7 alone. For purposes of this test, the additional injection of 200 to 300 gpm into the State 7 well was intended to compensate for the water lost as steam, and bring the system more nearly into balance.

Head Change in Pumping and Injection Wells

Depth to water in Well 45-7 was measured during and after pumping by means of a bubbler tube or airline, equipped with a pressure transducer. The open end of the bubbler tube was at a depth between 940 and 960 ft. The results of these measurements are shown on Figure 3A, the raw data, and Figure 3B, the calculated drawdown from non-pumping conditions. To prepare Figure 3B, many spurious measurements attributable to over-pressure during periodic purging of the bubbler tube, and to pressure loss from the bubbler tube between purges, were omitted, and the remaining data were expressed in terms of drawdown from a projected non-pumping level. The projection was made by extrapolation of a semi-log

plot of the recovery data to infinite time (t/t' = 1), to estimate the airline pressure at zero drawdown.

The apparent specific capacity of Well 45-7 was about 12.5 gpm per foot of drawdown at 925 gpm after about 7.8 days, and about 10.4 gpm per foot after an additional 5.8 days at pumping rates of 1,270 to 1,300 gpm. Pressure at the casing head in Well 55-7 during injection is shown on Figure 6.

Drawdown in Observation Wells

Depth to water in observation wells was measured in some wells for part of the test period with an electric water-level sounder, and relative water levels were taken in all wells for the entire period with dedicated pressure transducers. The transducers recorded the pressure in a nitrogen-charged bubbler tube or airline in each well.

Water-level data from the pressure transducers are shown in terms of drawdown from pre-test levels on Figure 3B, and Figures 8 through 19. Where hand measurements with an electric sounder were taken, they are also shown on the graphs. In all cases, the transducer measurements represent the raw output in pounds per square inch, converted to feet of water. Because the depth to the open end of the airline in each well could not be measured accurately, the plotted measurements as shown on the graphs were offset to match the earliest corresponding "hand" measurement made with the water-level sounder. Where no hand measurements were taken, the initial transducer measurement was assumed to represent zero drawdown.

Little House Well: Hand measurements in this shallow well showed a small rise in water level for the first 8 days of the test (Fig. 8). Transducer measurements showed a large diurnal range, but little trend during the course of the test.

Well G-6-W: No hand measurements were taken in this shallow well. The transducer measurements (Fig. 9) show a large diurnal fluctuation and total decline of about 8.5 ft.

Well G-3-S: No hand measurements were taken in this shallow well. The transducer measurements (Fig. 10) show a large diurnal fluctuation and total decline of about 11 ft. There were many spurious readings.

Well A-133: Both hand measurements and transducer measurements (except for a number of spurious readings in the early part of the test) show essentially no change during the

course of the test (Fig. 11). This shallow well may not be in connection with the shallow aquifer.

Well G-2-SE: No hand measurements were taken in this 400-ft well. The transducer measurements (Fig. 12) show a large diurnal fluctuation and total decline of about 5 ft as measured between daily high levels.

Well A-132: Hand measurements in this shallow well show a general rise totaling about 1.5 ft during the first 8 days of the test (Fig. 13). The transducer measurements, on the other hand, suggest a slight downward trend of about 0.15 feet per day during the entire test.

Well A-131: Hand measurements in this shallow well were taken for only 3 days. Transducer measurements (Fig. 14) show a downward trend and a total decline of about 5.5 ft.

Twenty-Acres Well: Hand measurements in this 1,000-ft well indicate a slow rise totaling about 1 ft during the first 8 days of the test (Fig. 15). The transducer measurements show essentially no change during the test.

State No. 3 Well: Only two hand measurements were taken in this well. Transducer measurements began after about 6 days, and show a decline of about 3.7 ft (Fig. 16).

McCants West Well: Apart from diurnal fluctuation, and many spurious transducer measurements early in the test, both the hand and transducer measurements indicate essentially no change in water level in this 994-ft well (Fig. 17).

McCants East Well: Apart from diurnal fluctuation, and many spurious transducer measurements early in the test, both the hand and transducer measurements indicate essentially no change in water level in this 2,209-ft well (Fig. 18).

Well A-125: Both hand measurements and transducer measurements show an initial decline of 4 to 5 ft, ending about 3 days into the test, then a rise in water level during the remainder of the test (Fig. 19).

SUMMARY

Water levels in wells in the immediate vicinity of the geothermal wells (see Fig. 1) rose in some cases and declined in others, with a maximum decline of about 11 ft. In wells outside the immediate geothermal area, represented by the McCants West, Little House, and Twenty Acres wells, there was no significant change in water level attributable to the test.

ILLUSTRATIONS

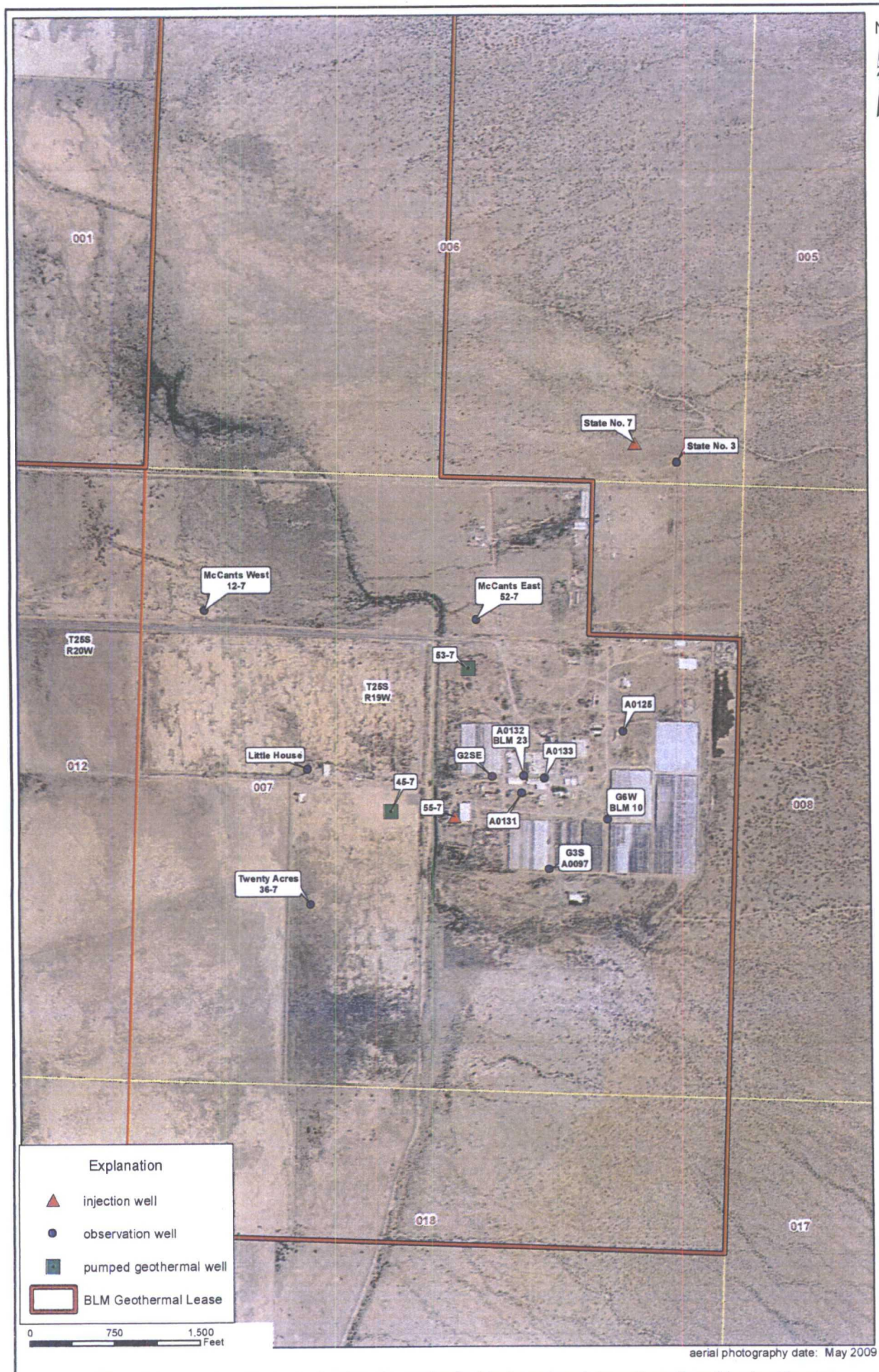

Figure 1. Aerial photograph showing locations of pumped wells, injection wells, and observation wells used for closed-loop test, January 16 through February 3, 2012.

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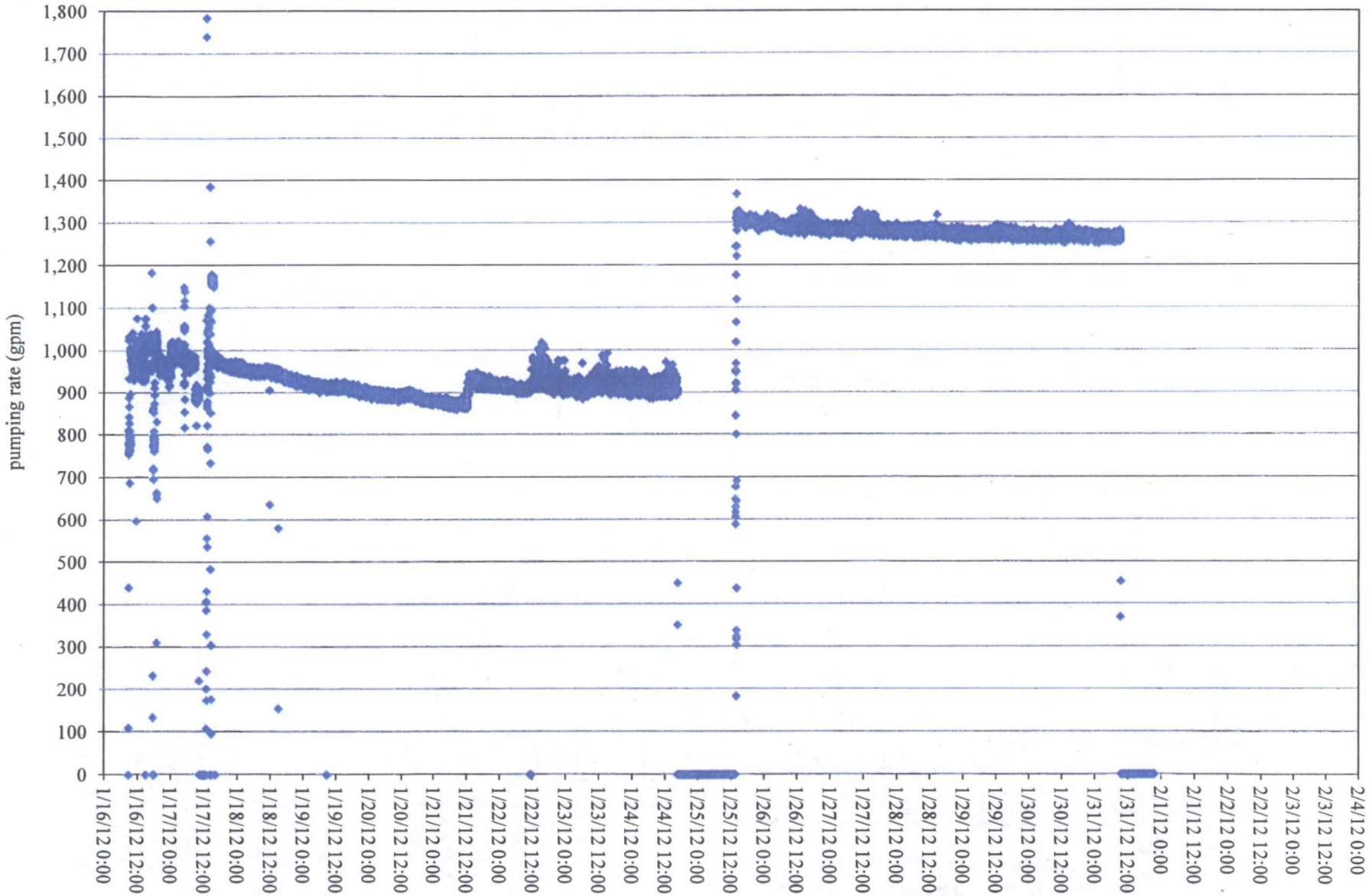

Figure 2. Pumping rate, Well 45-7 (measured by differential pressure at orifice plate).

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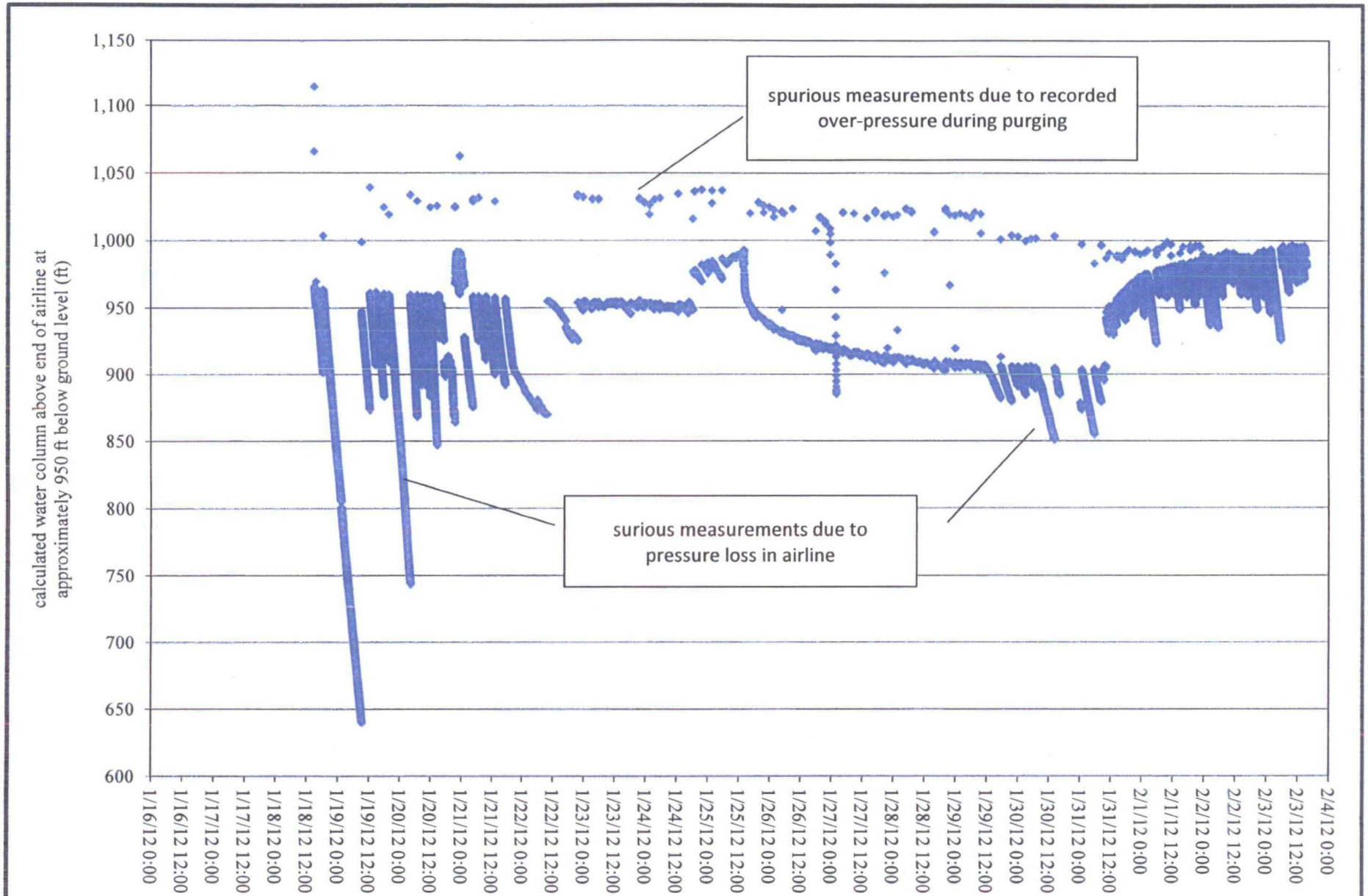

Figure 3A. Depth to water in Well 45-7 during closed-loop test.

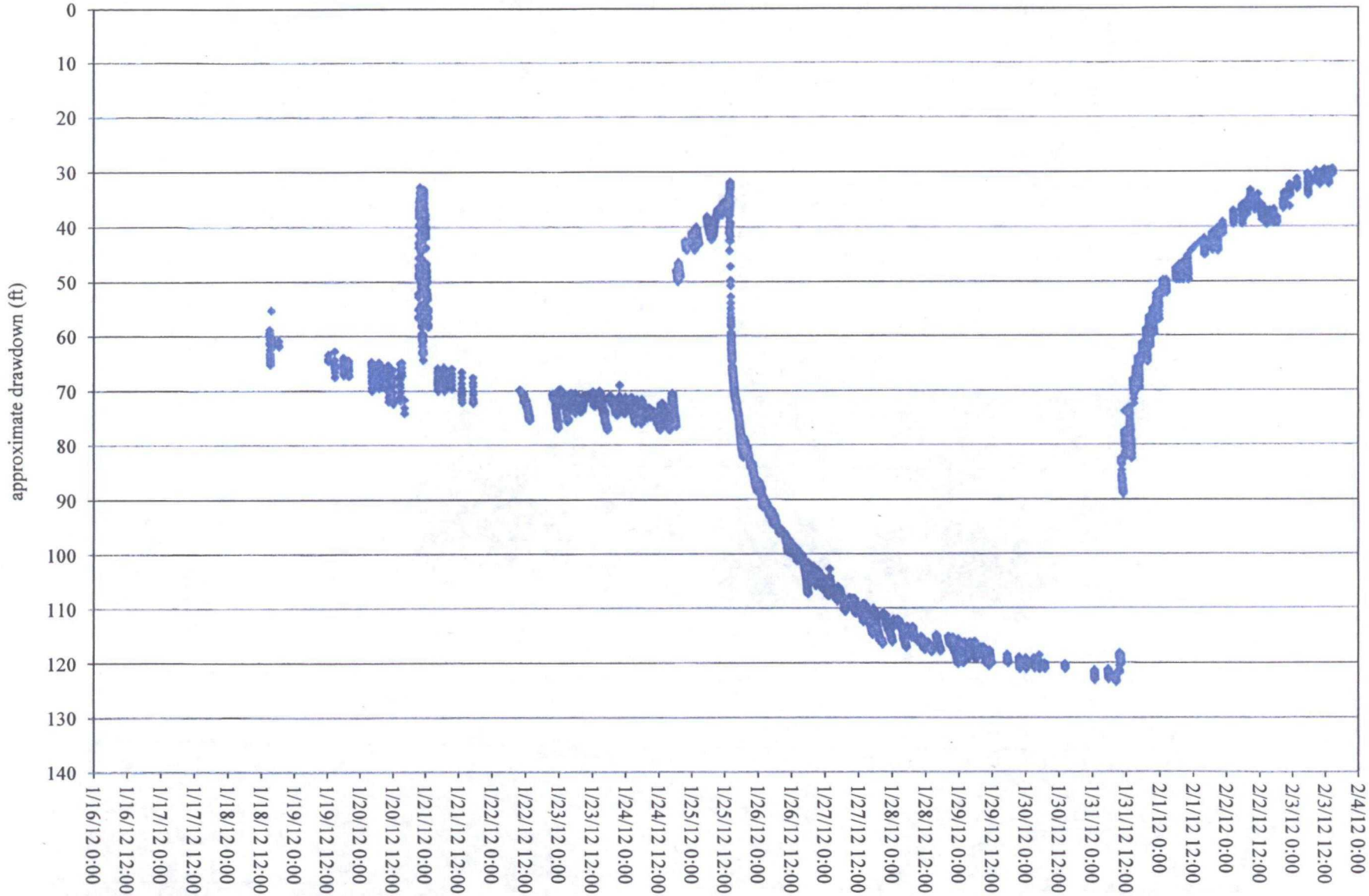

Figure 3B. Approximate drawdown in Well 45-7 during closed-loop test.

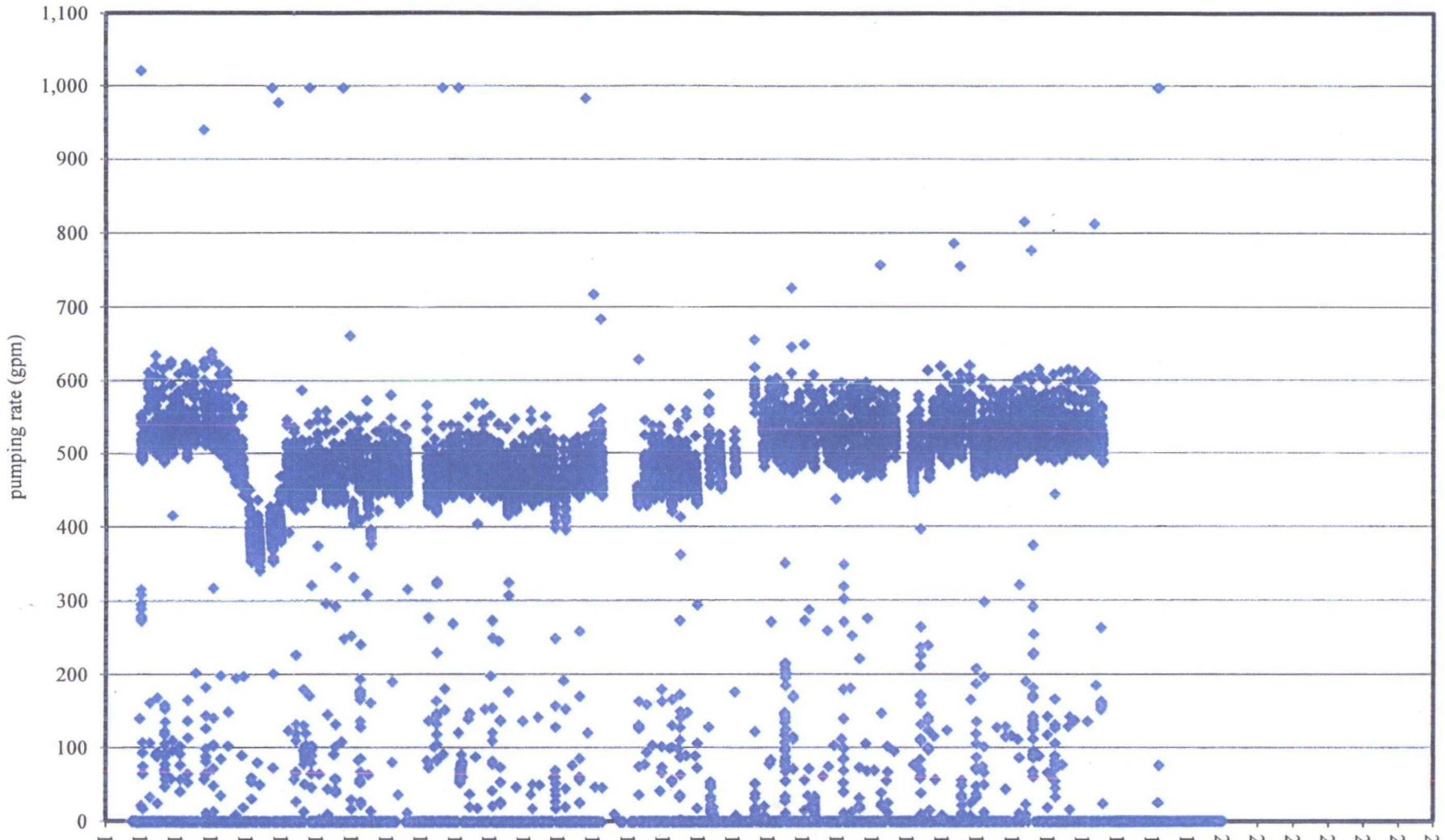

Figure 4. Pumping rate, Well 53-7 (flow rate through pipe after storage tank).

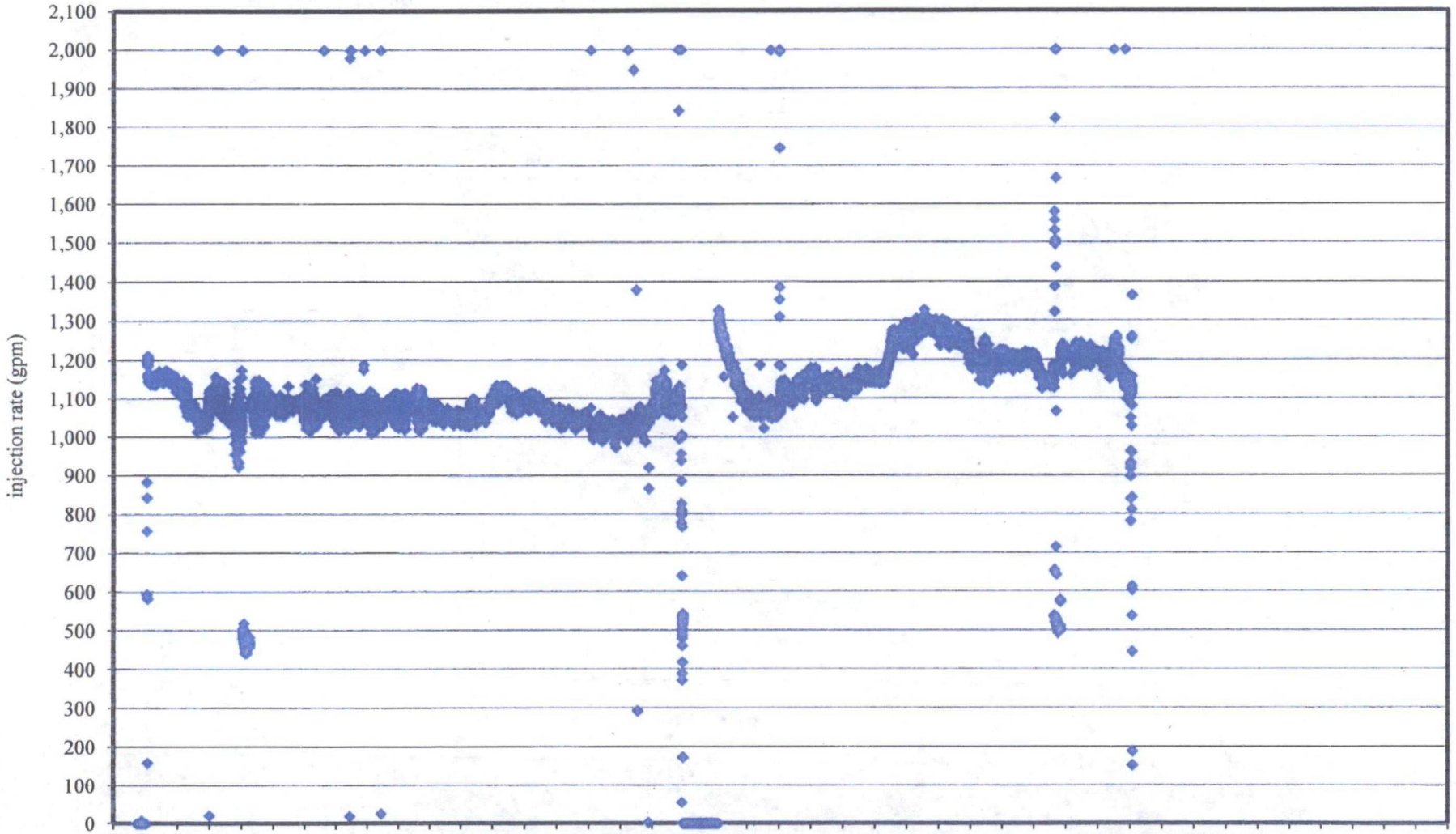

Figure 5. Injection rate, Well 55-7.

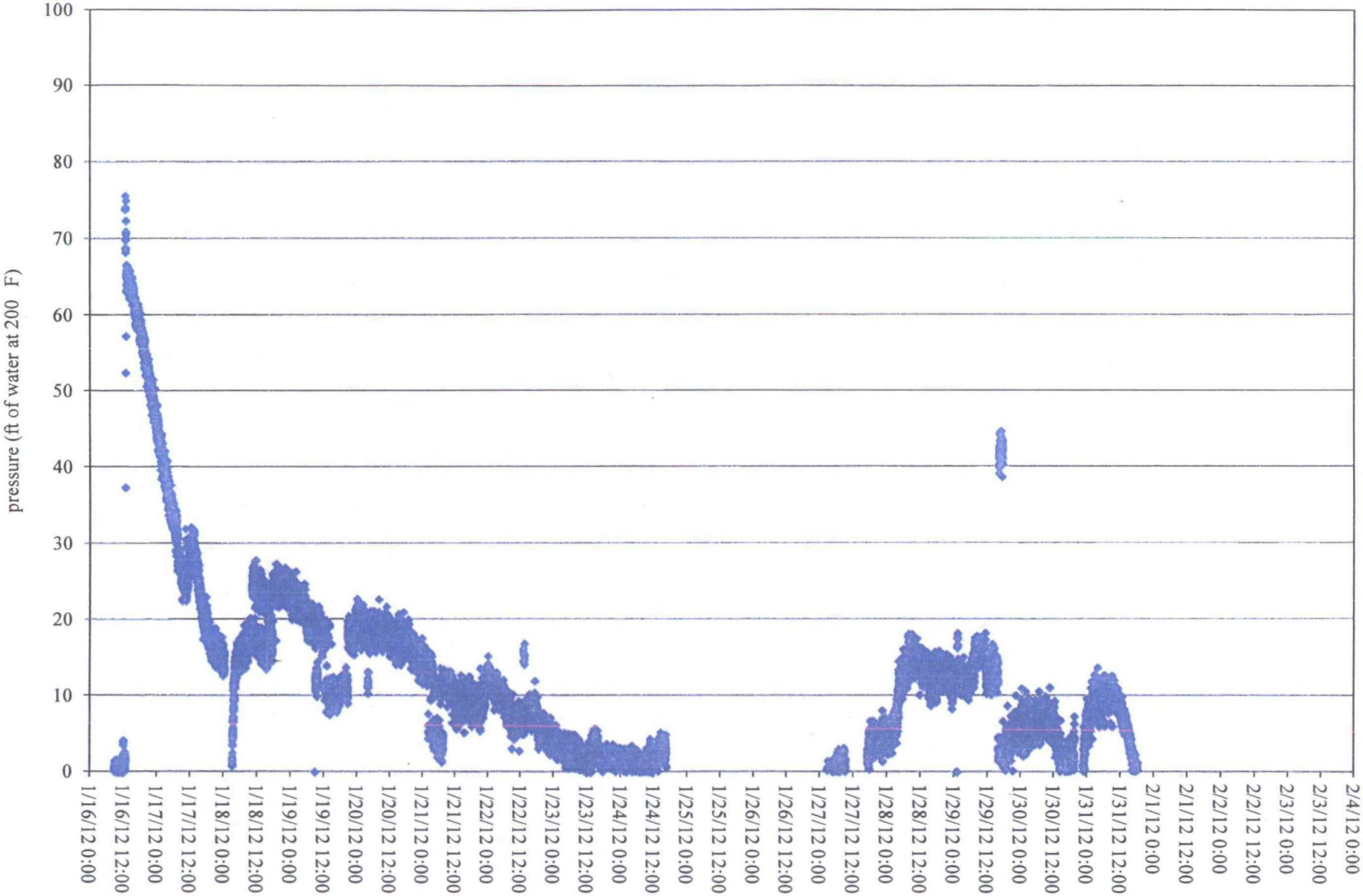

Figure 6. Injection pressure at wellhead, Well 55-7, feet of water at 200° F.

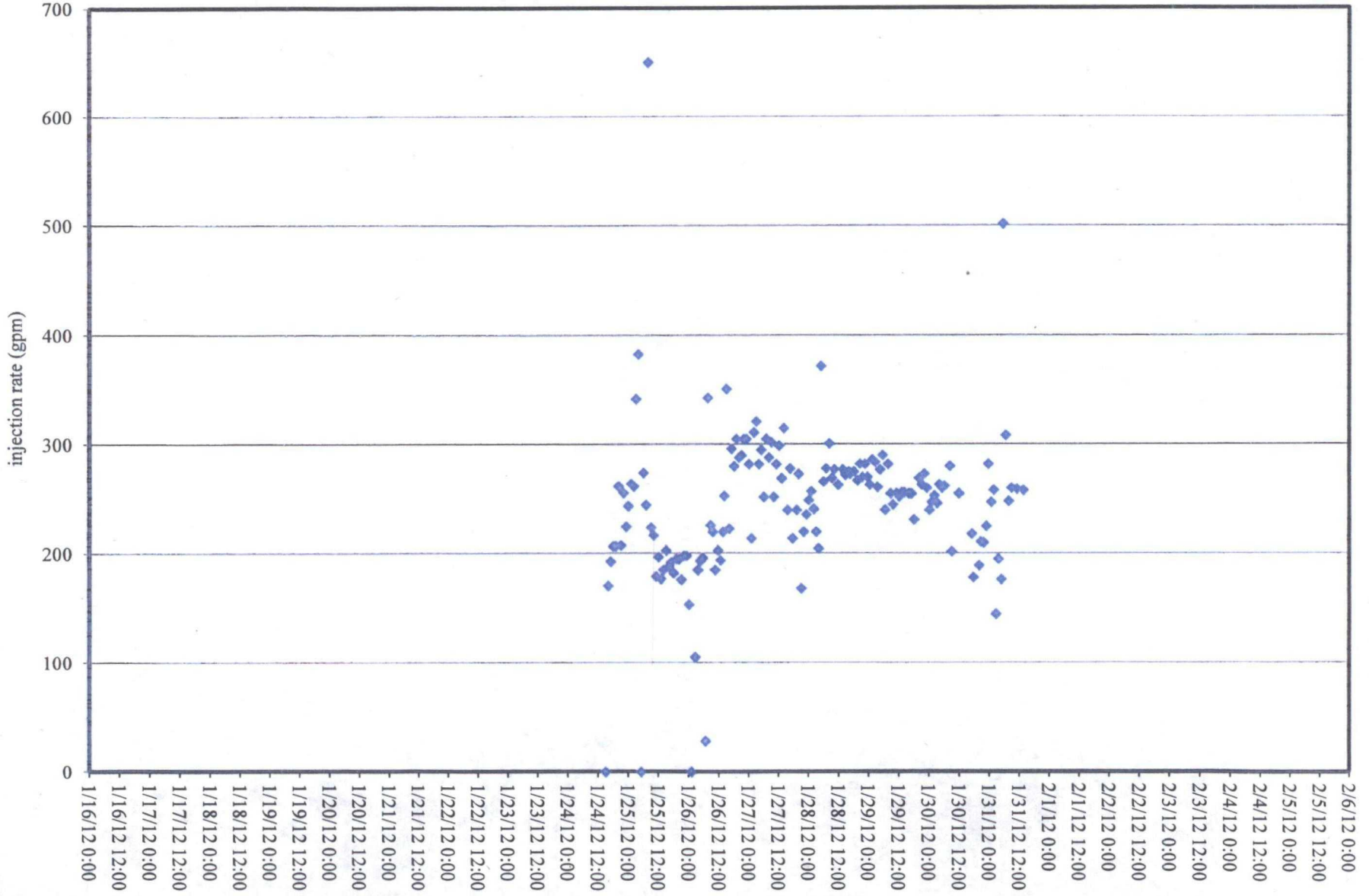

Figure 7. Injection rate, State No. 7 well during closed-loop test (water supplied off-site from fresh water source).

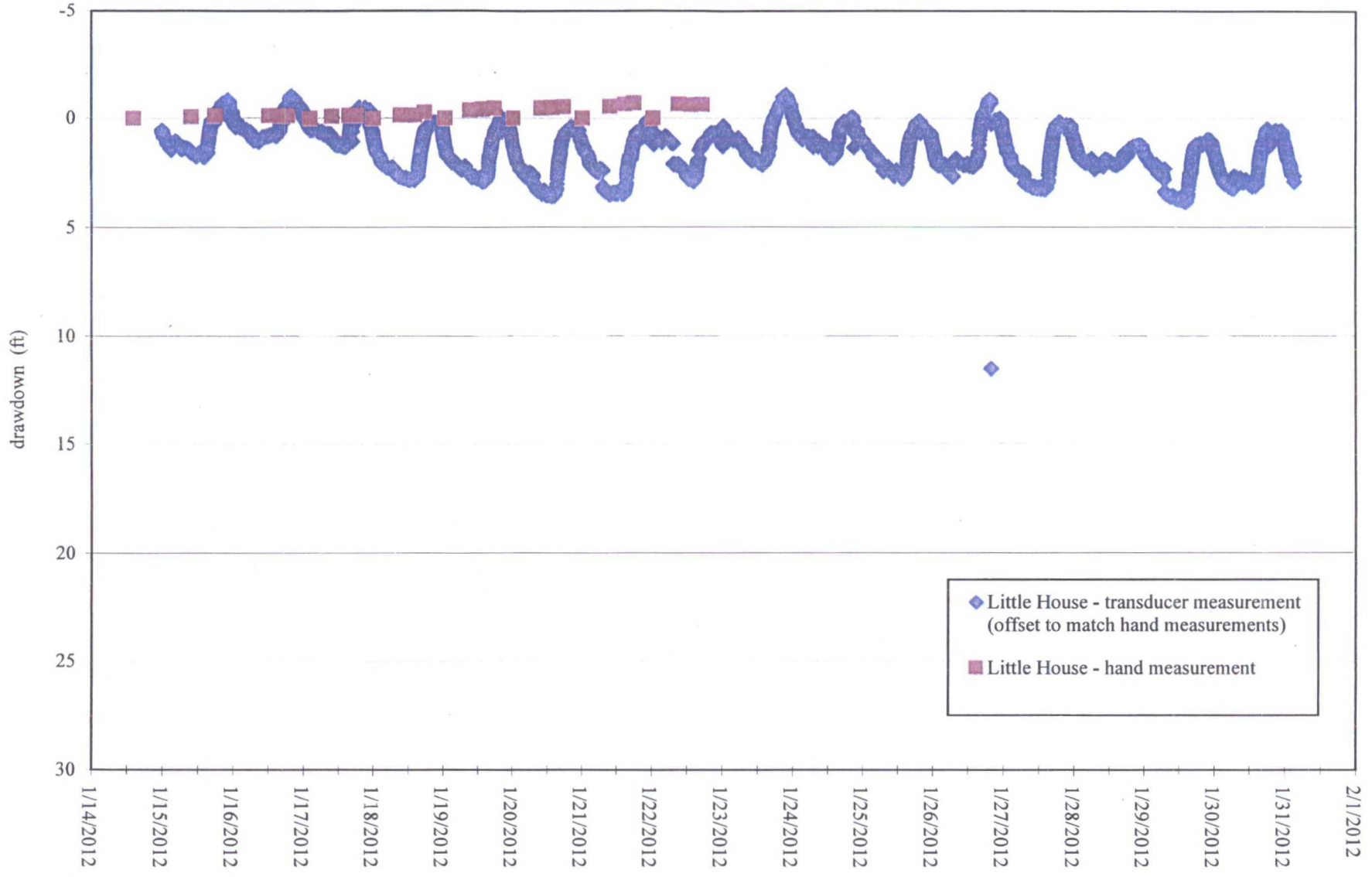

Figure 8. Drawdown in Little House Well during closed-loop test.

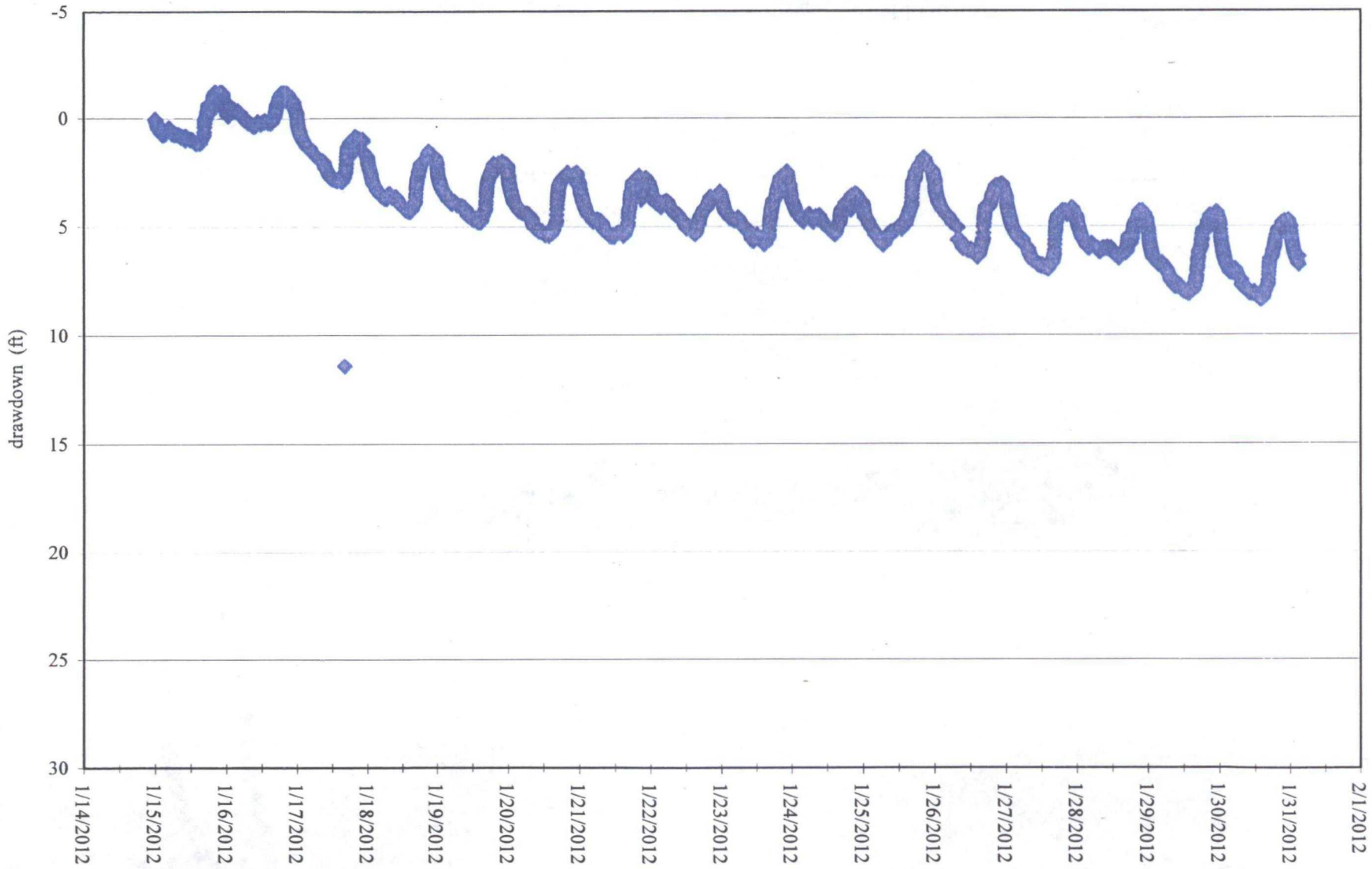

Figure 9. Drawdown in Well G-6-W during closed-loop test.

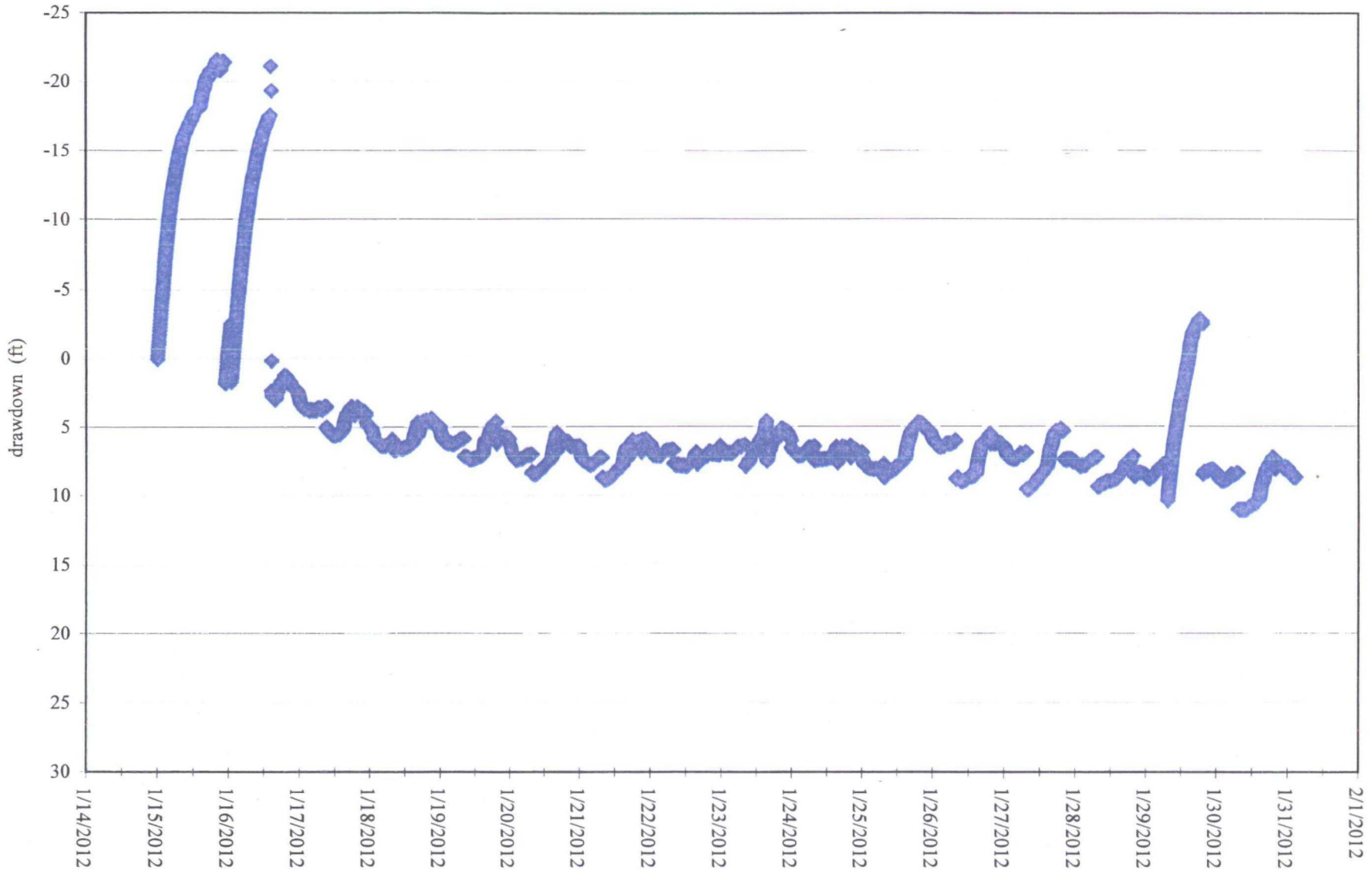

Figure 10. Drawdown in Well G-3-S during closed-loop test.

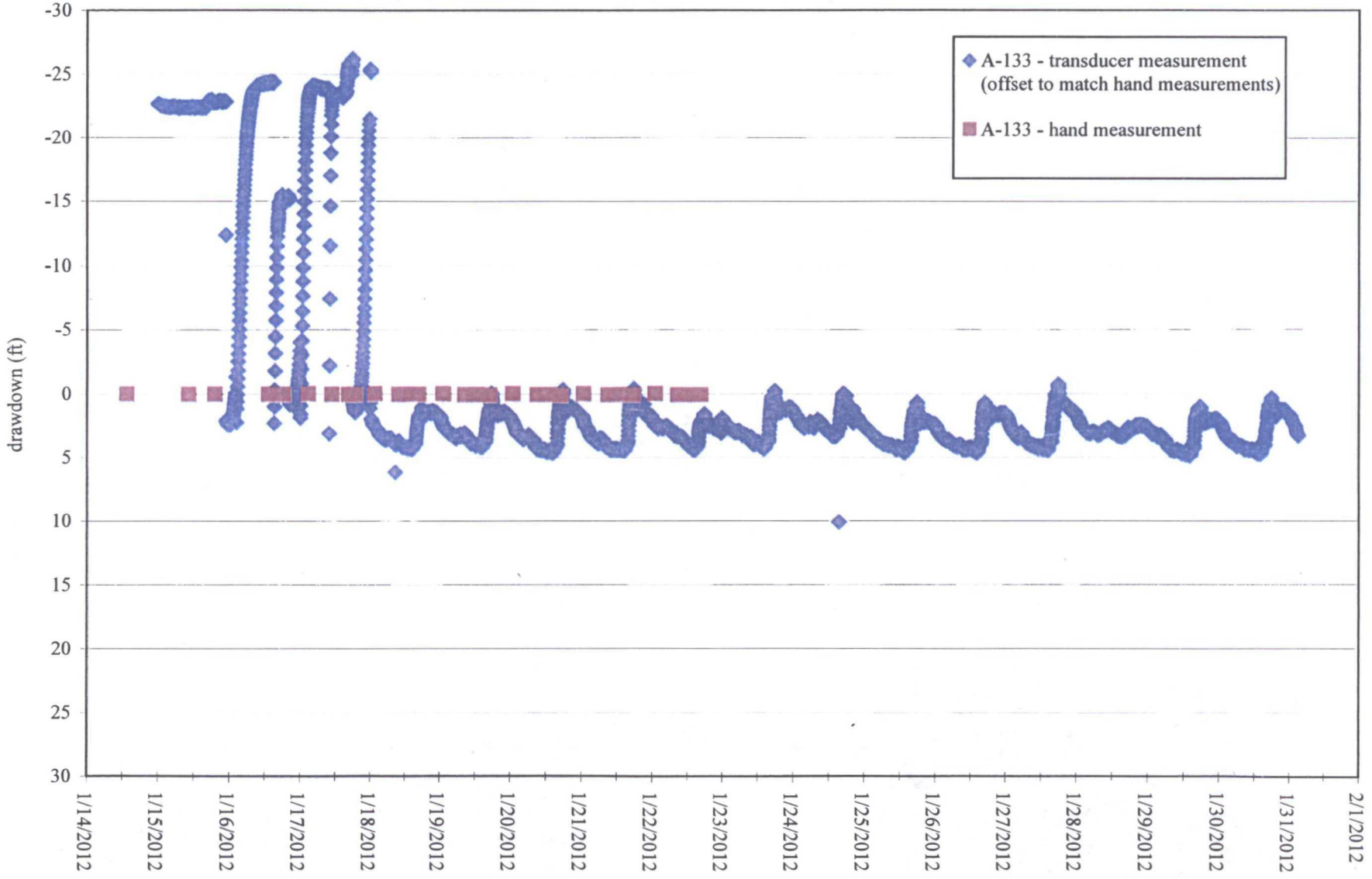

Figure 11. Drawdown in Well A-133 during closed-loop test.

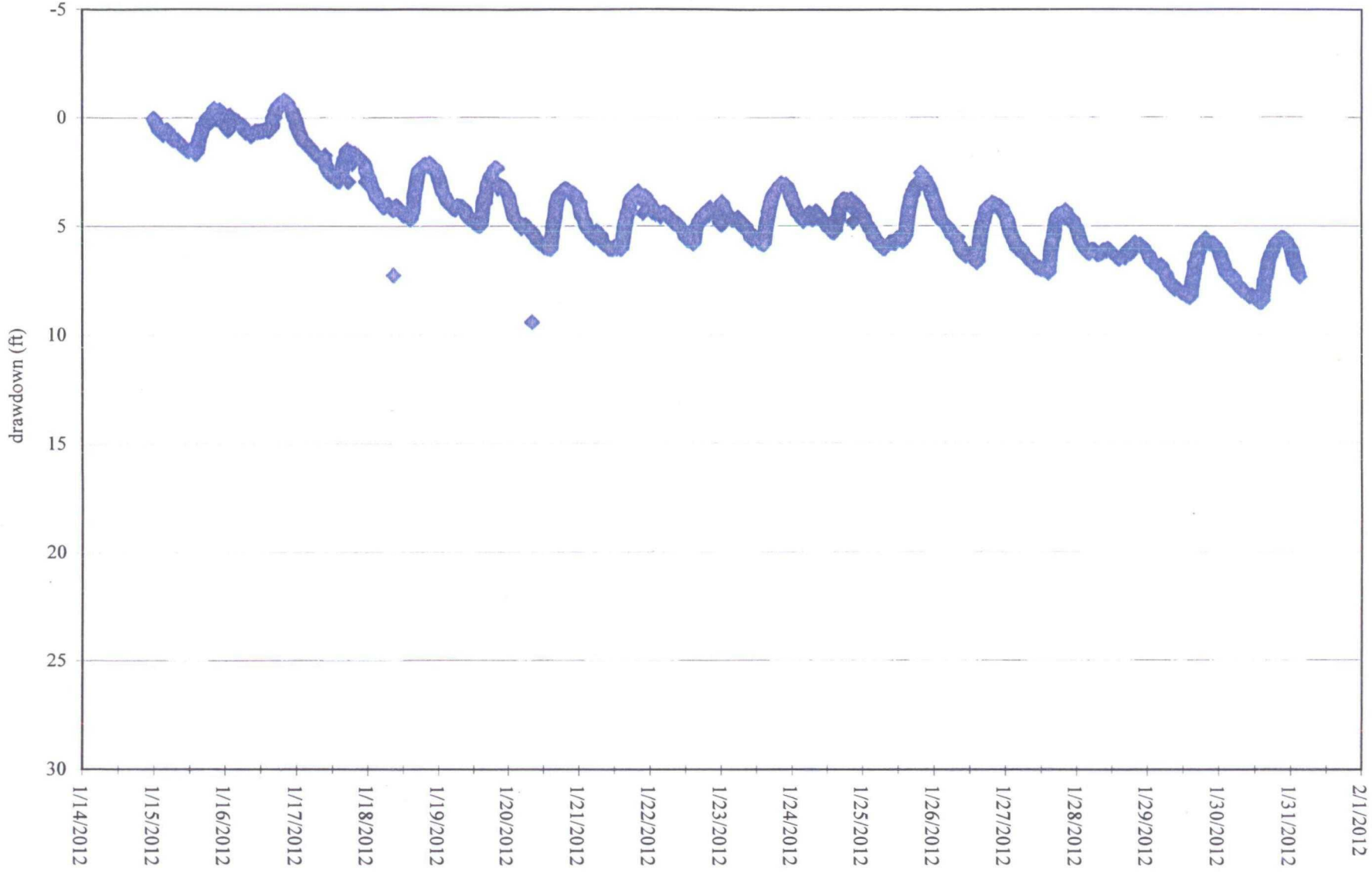

Figure 12. Drawdown in Well G-2-SE during closed-loop test.

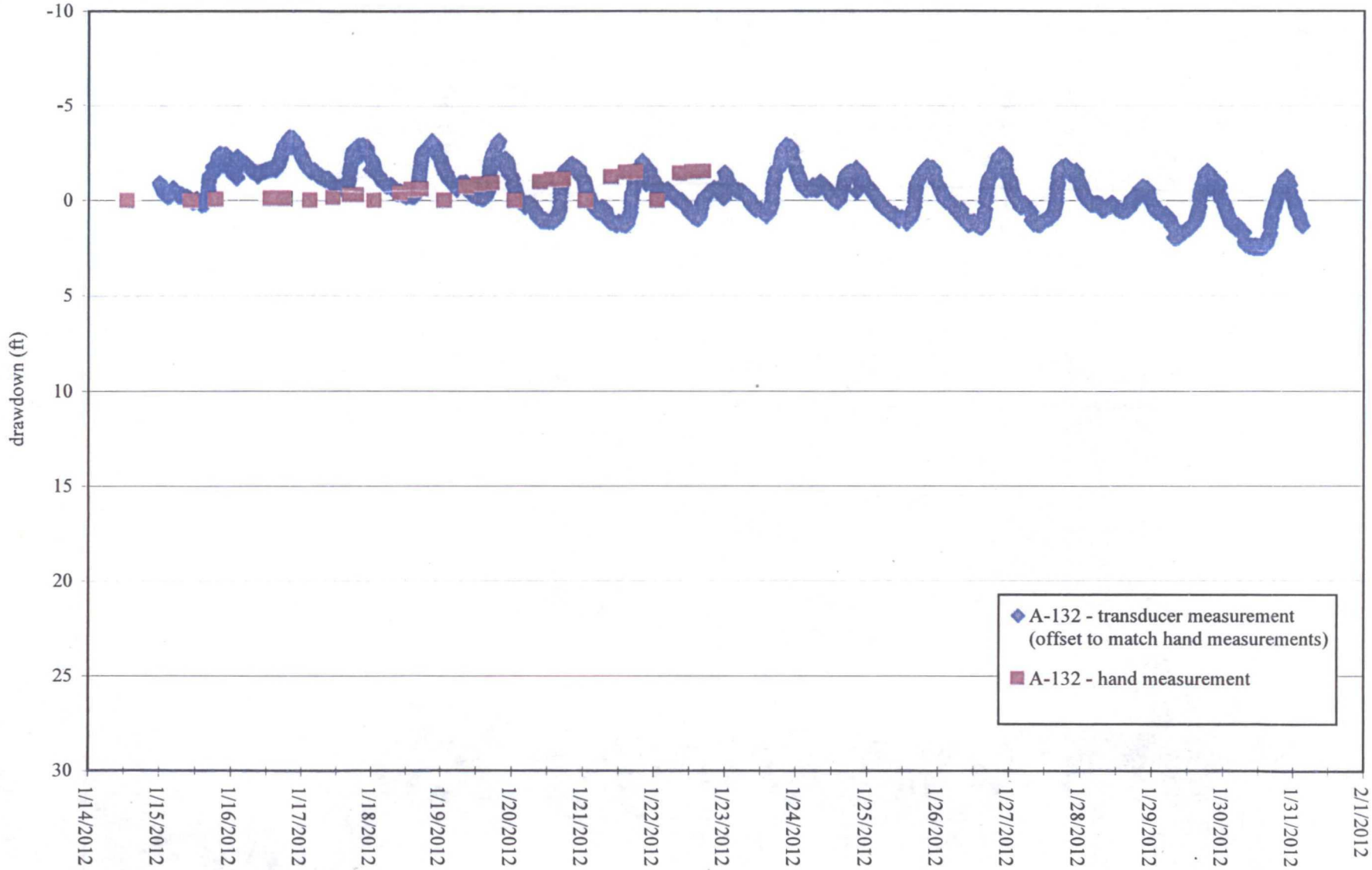

Figure 13. Drawdown in Well A-132 during closed-loop test.

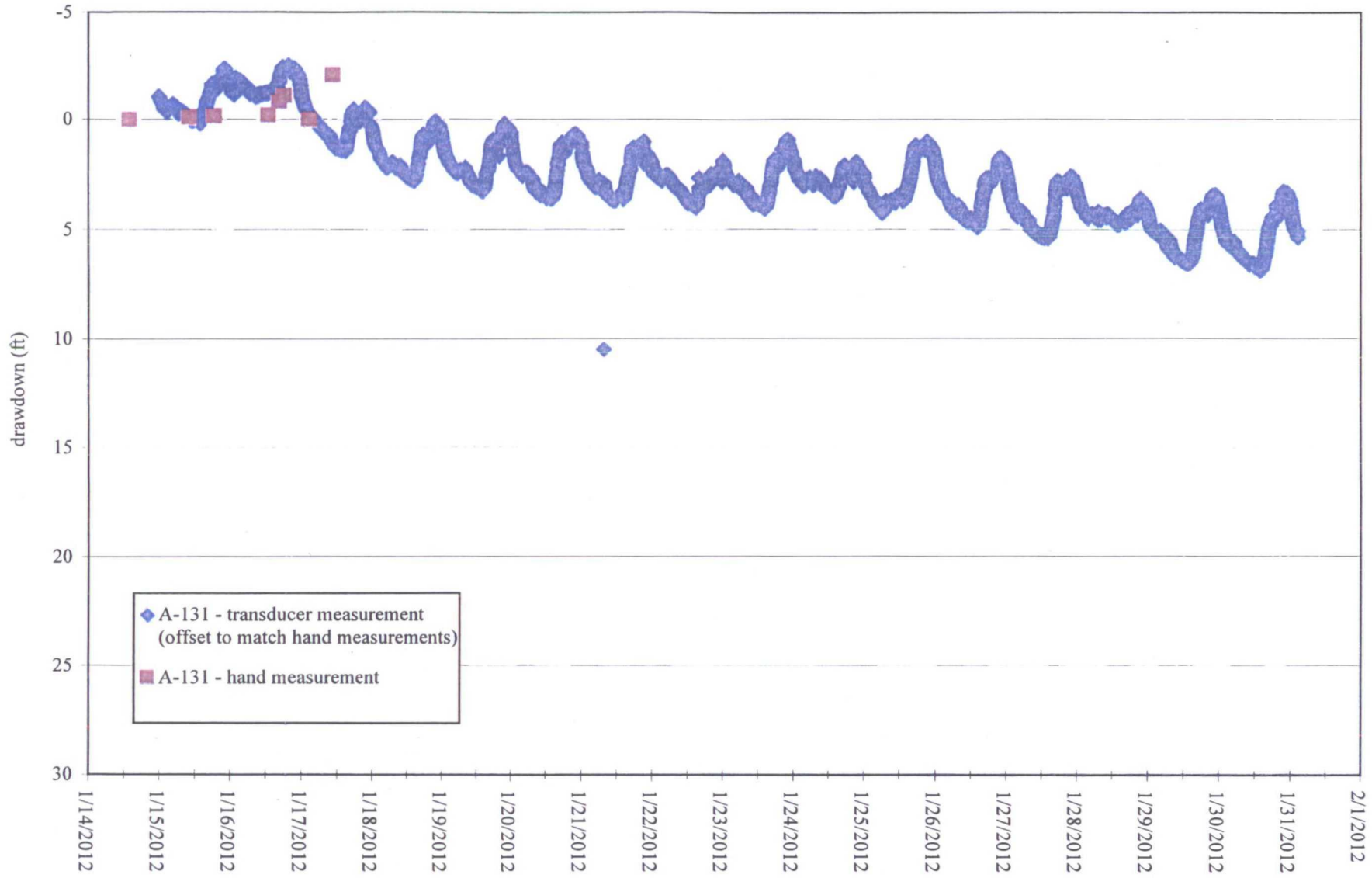

Figure 14. Drawdown in Well A-131 during closed-loop test.

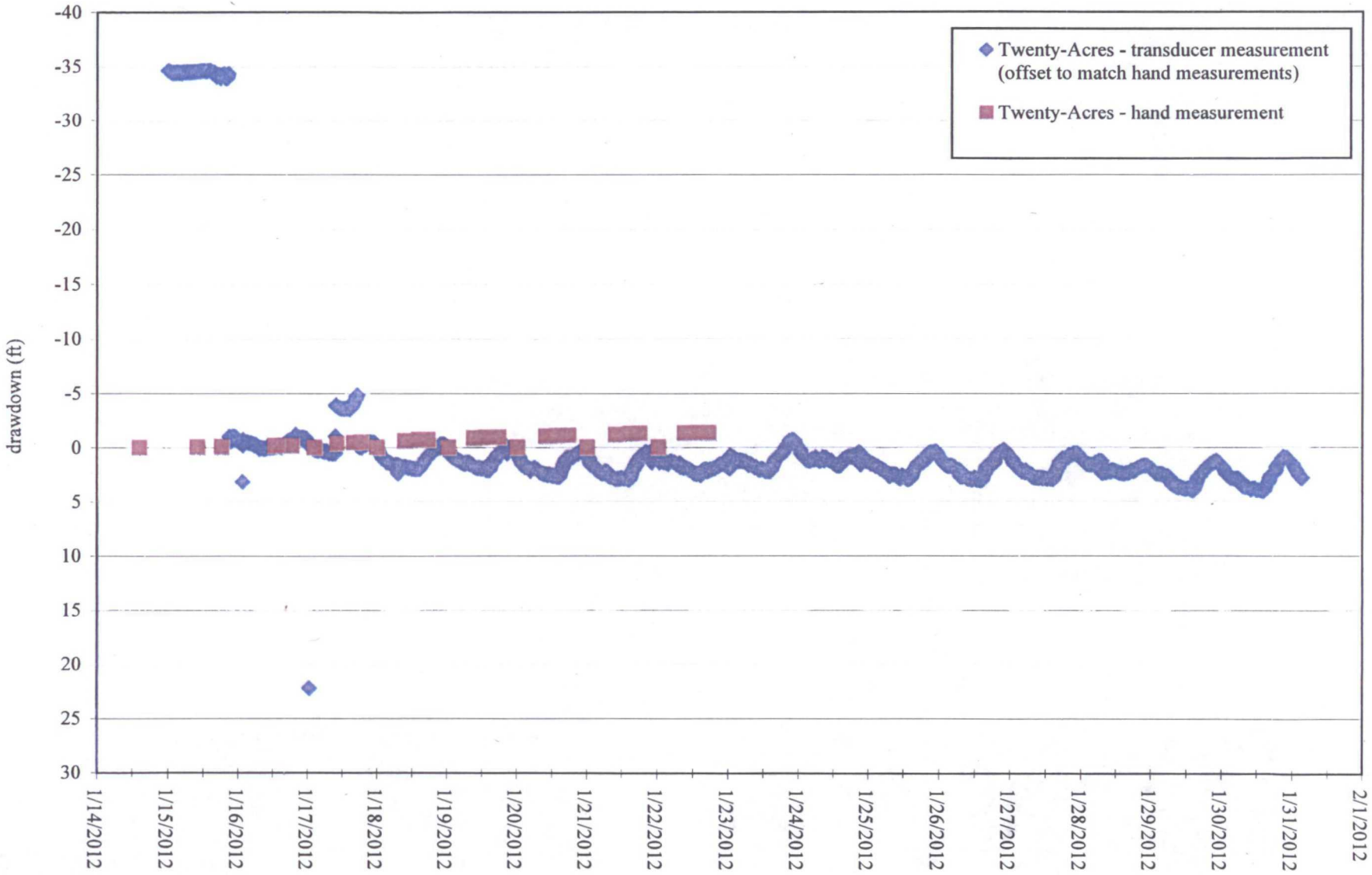

Figure 15. Drawdown in Twenty-Acres Well during closed-loop test.

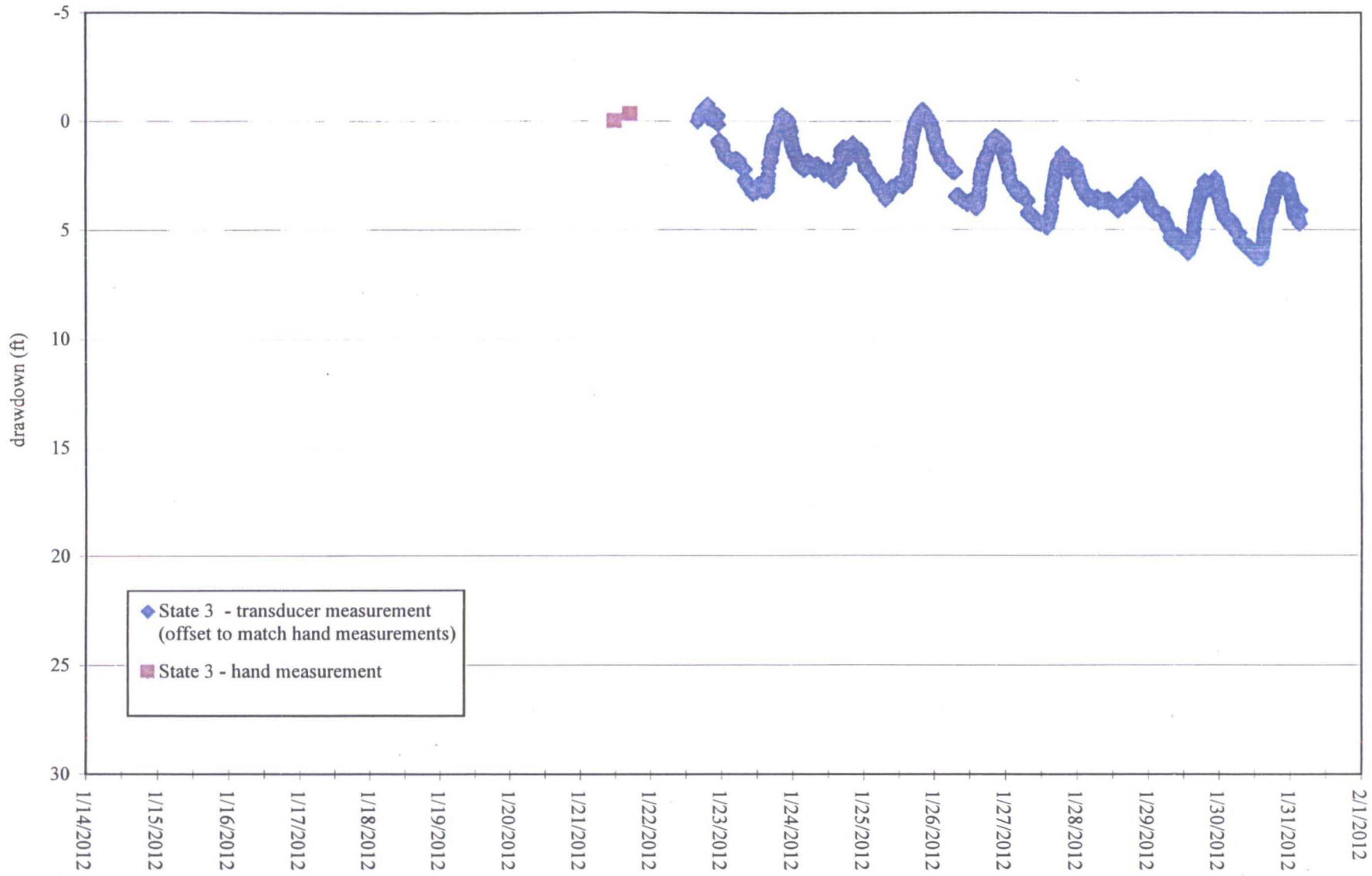

Figure 16. Drawdown in State No. 3 Well during closed-loop test.

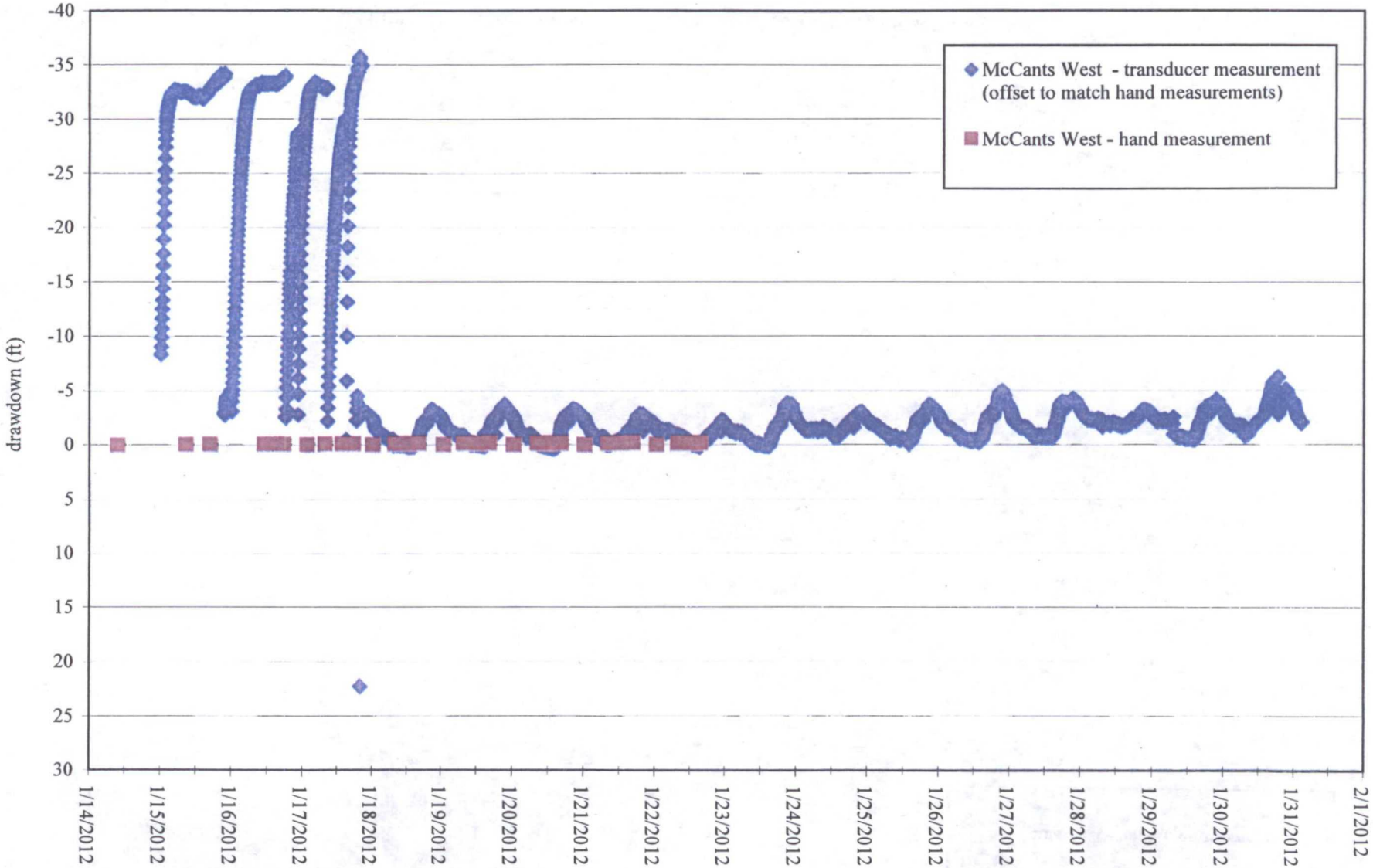

Figure 17. Drawdown in McCants West Well during closed-loop test.

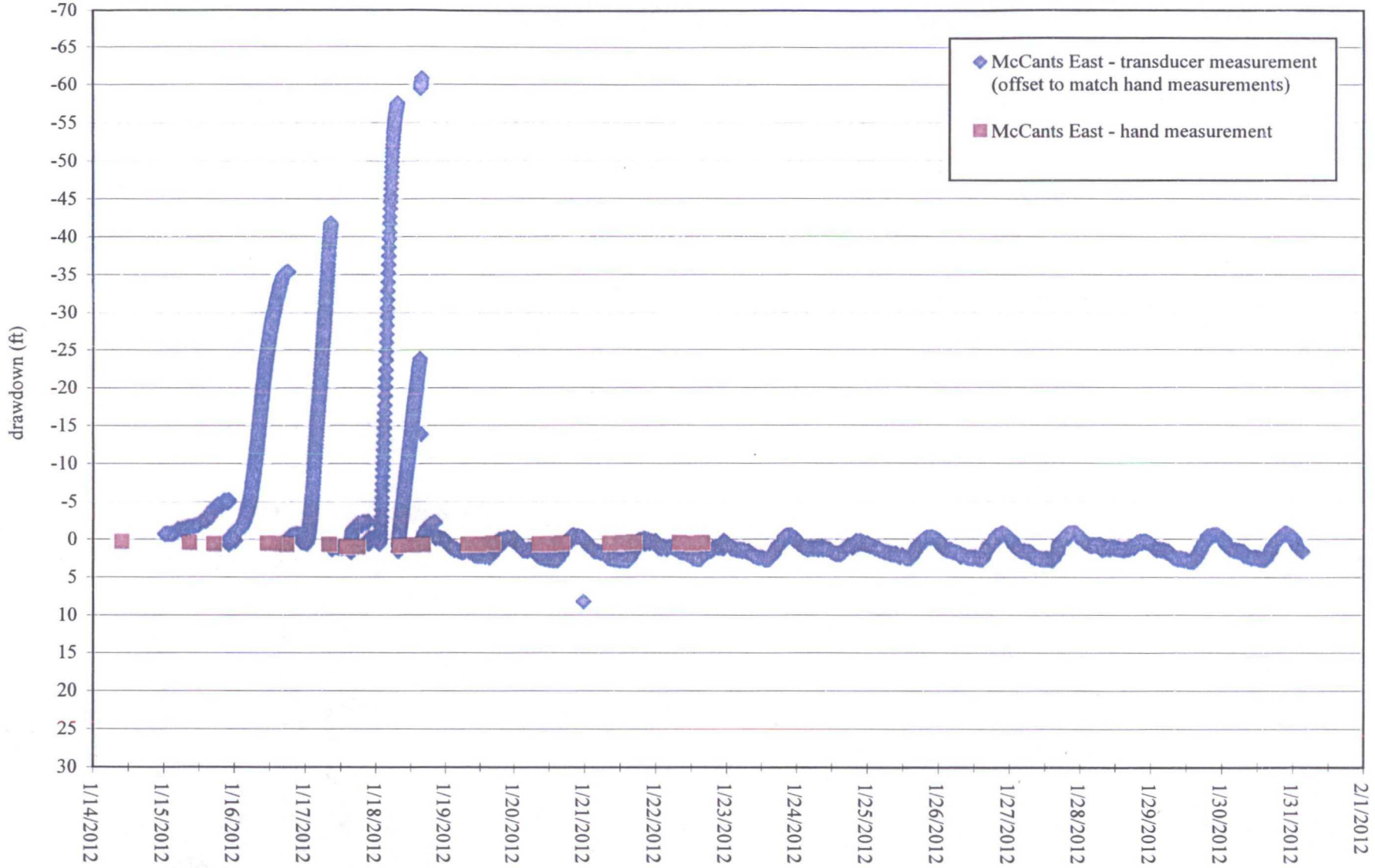

Figure 18. Drawdown in McCants East Well during closed-loop test.

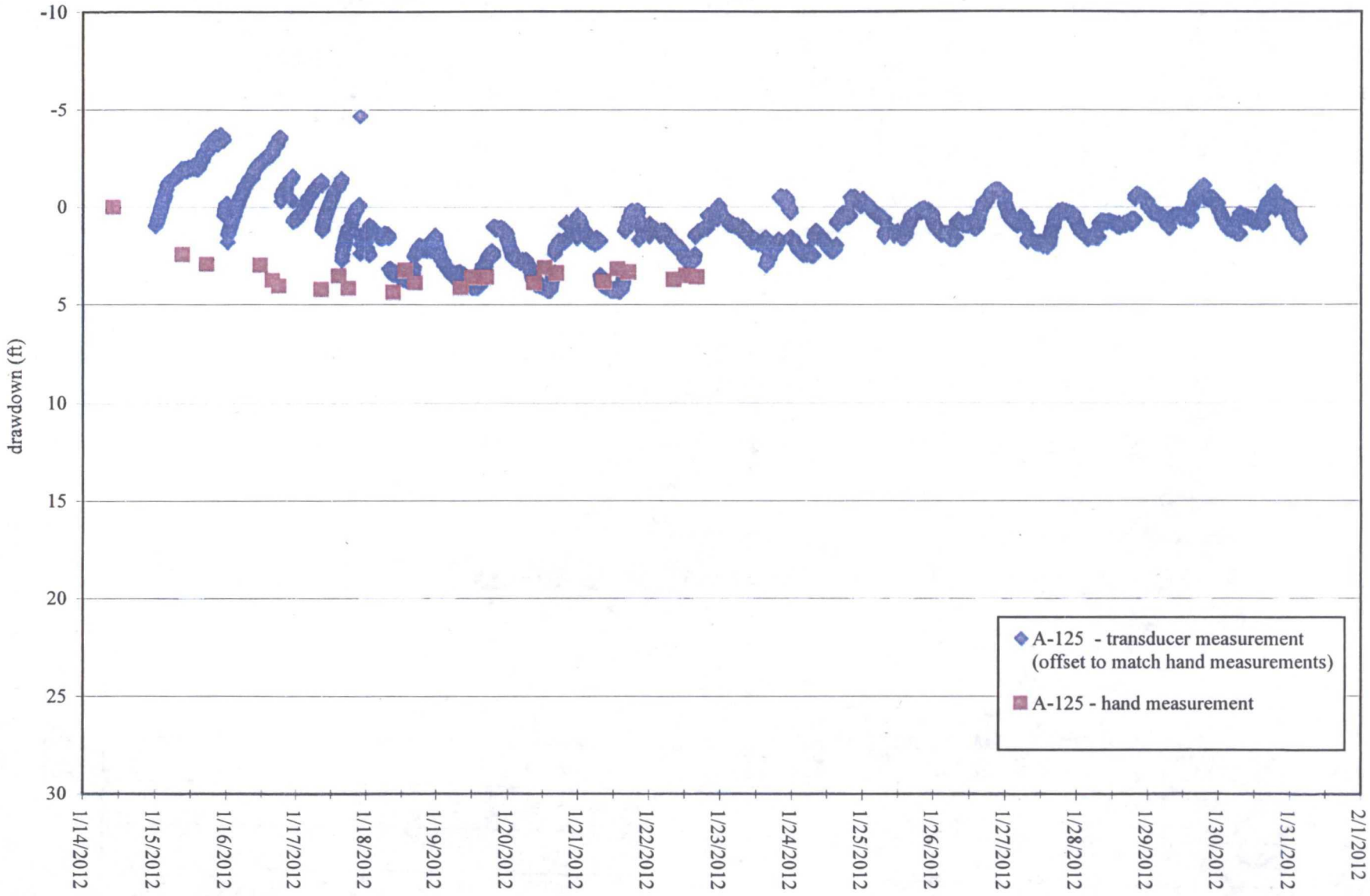

Figure 19. Drawdown in Well A-125 during closed-loop test.

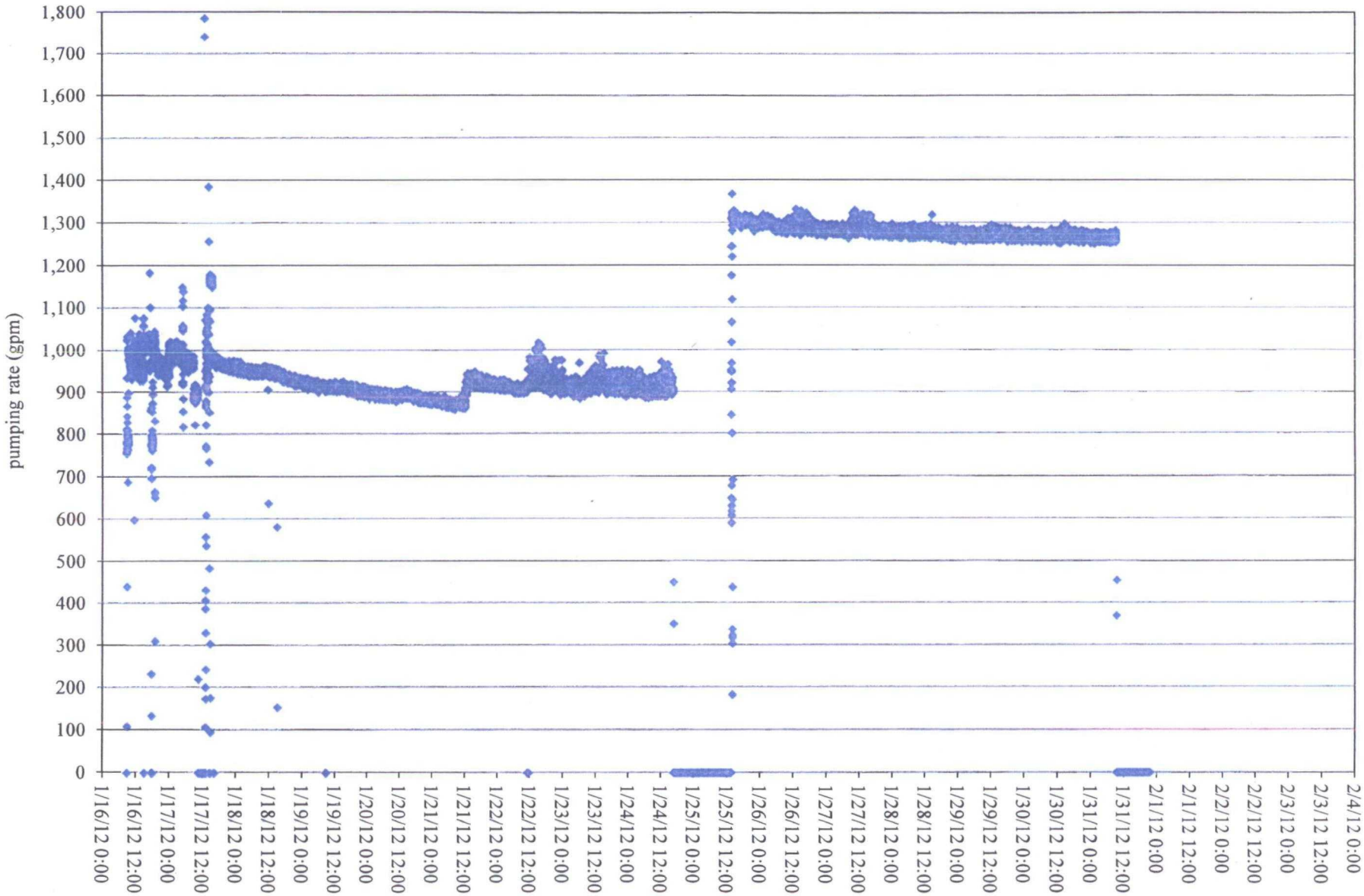

Figure 2. Pumping rate, Well 45-7 (measured by differential pressure at orifice plate).

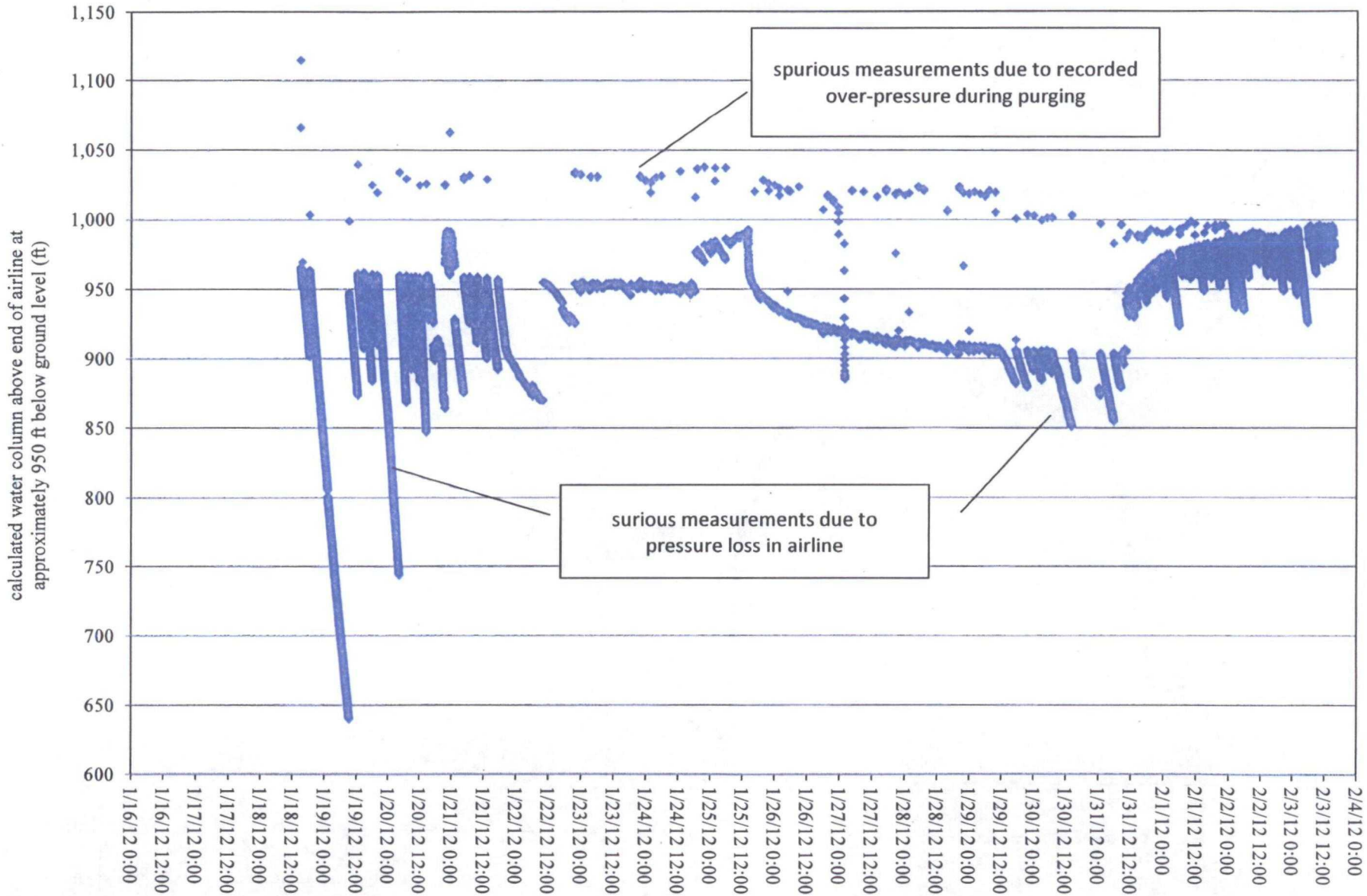

Figure 3A. Depth to water in Well 45-7 during closed-loop test.

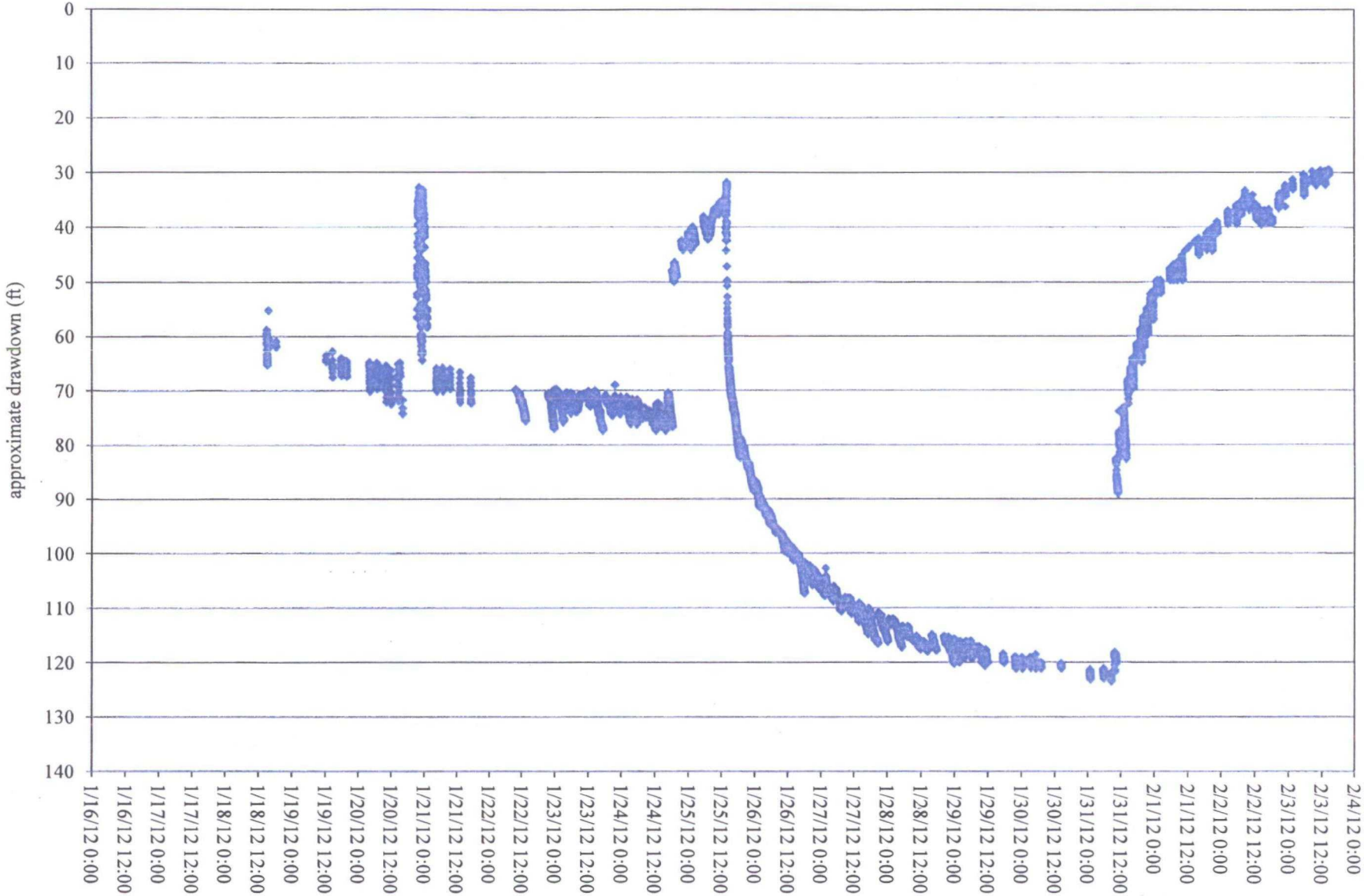

Figure 3B. Approximate drawdown in Well 45-7 during closed-loop test.

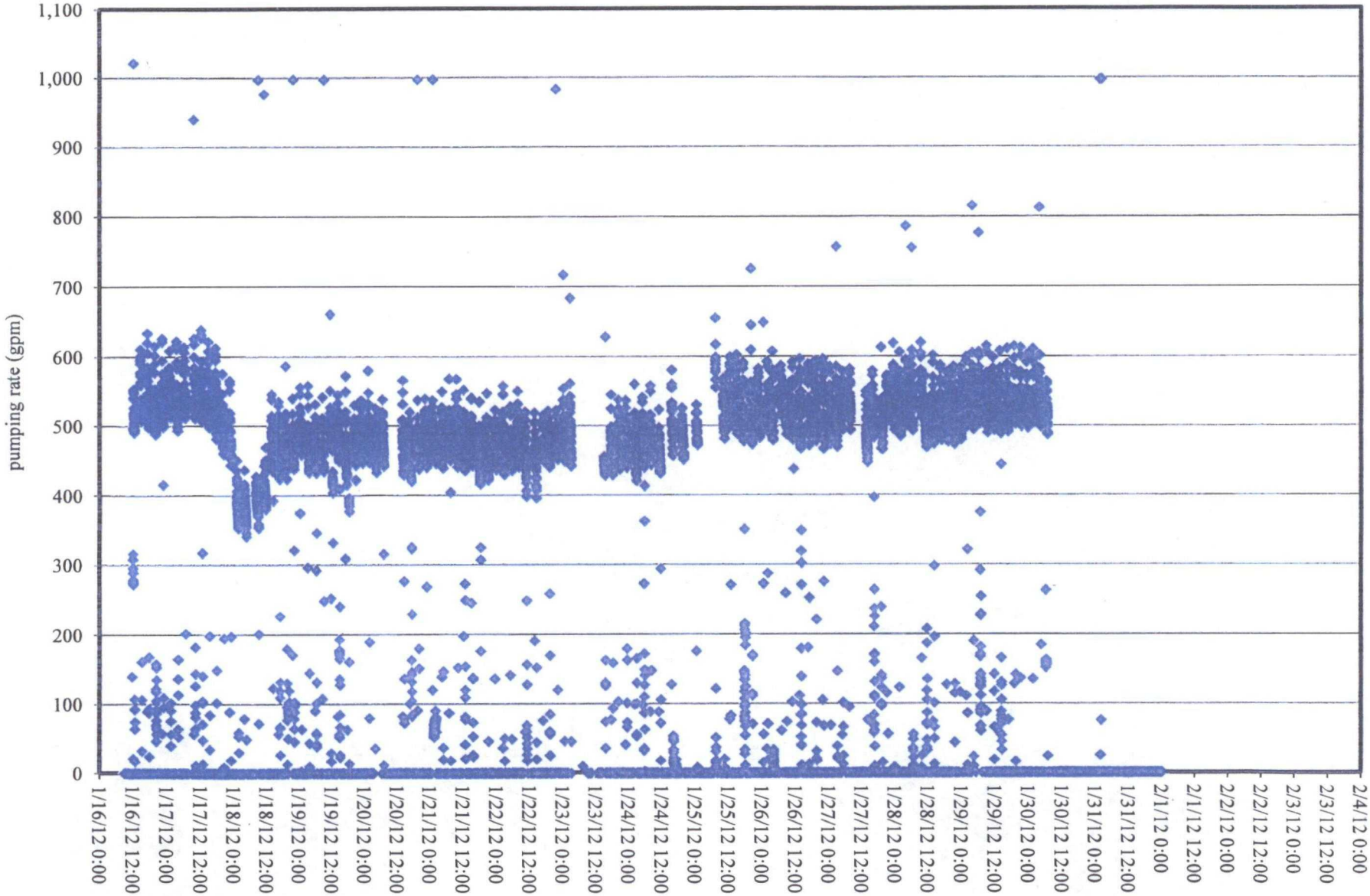

Figure 4. Pumping rate, Well 53-7 (flow rate through pipe after storage tank).

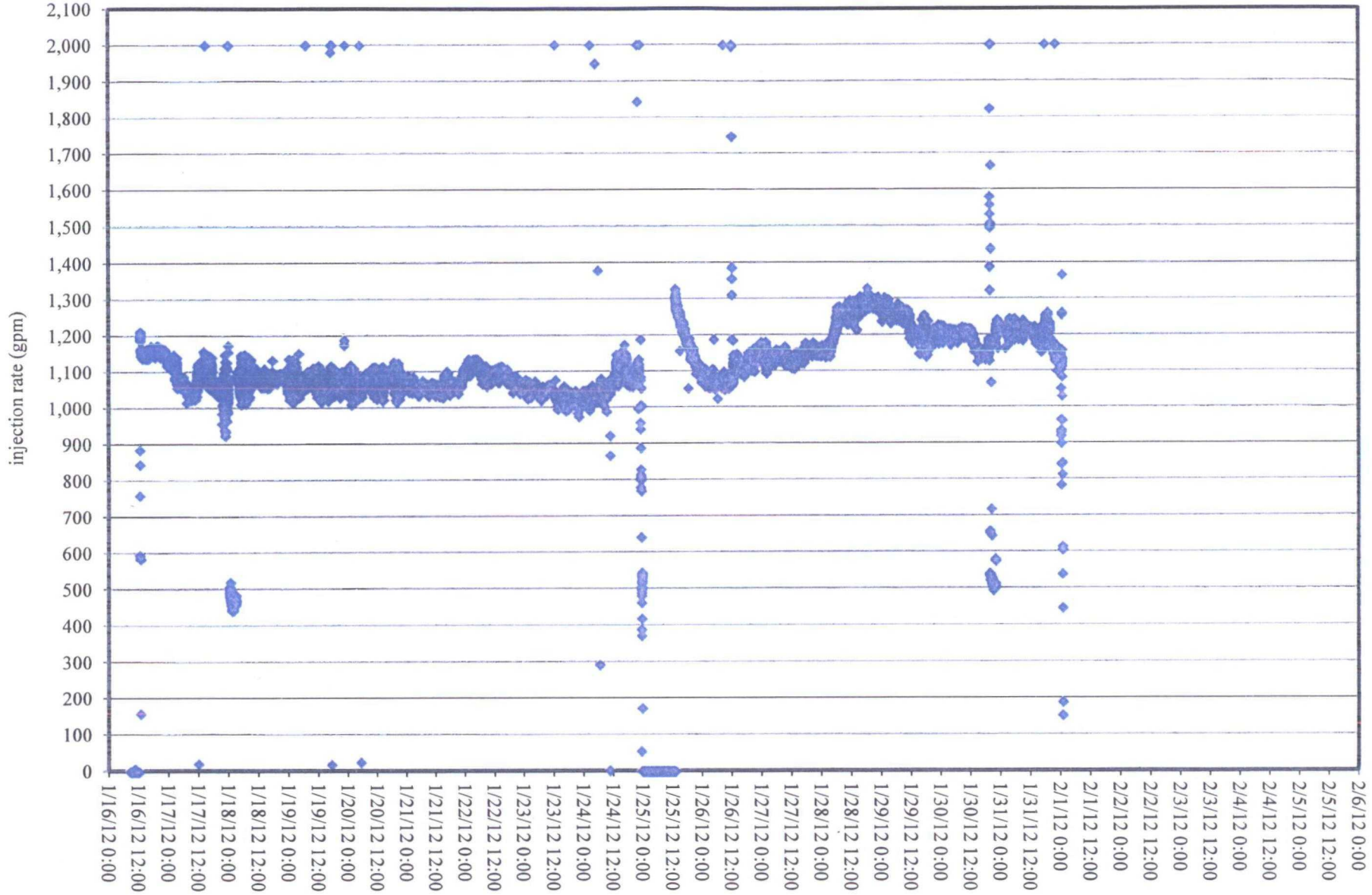

Figure 5. Injection rate, Well 55-7.

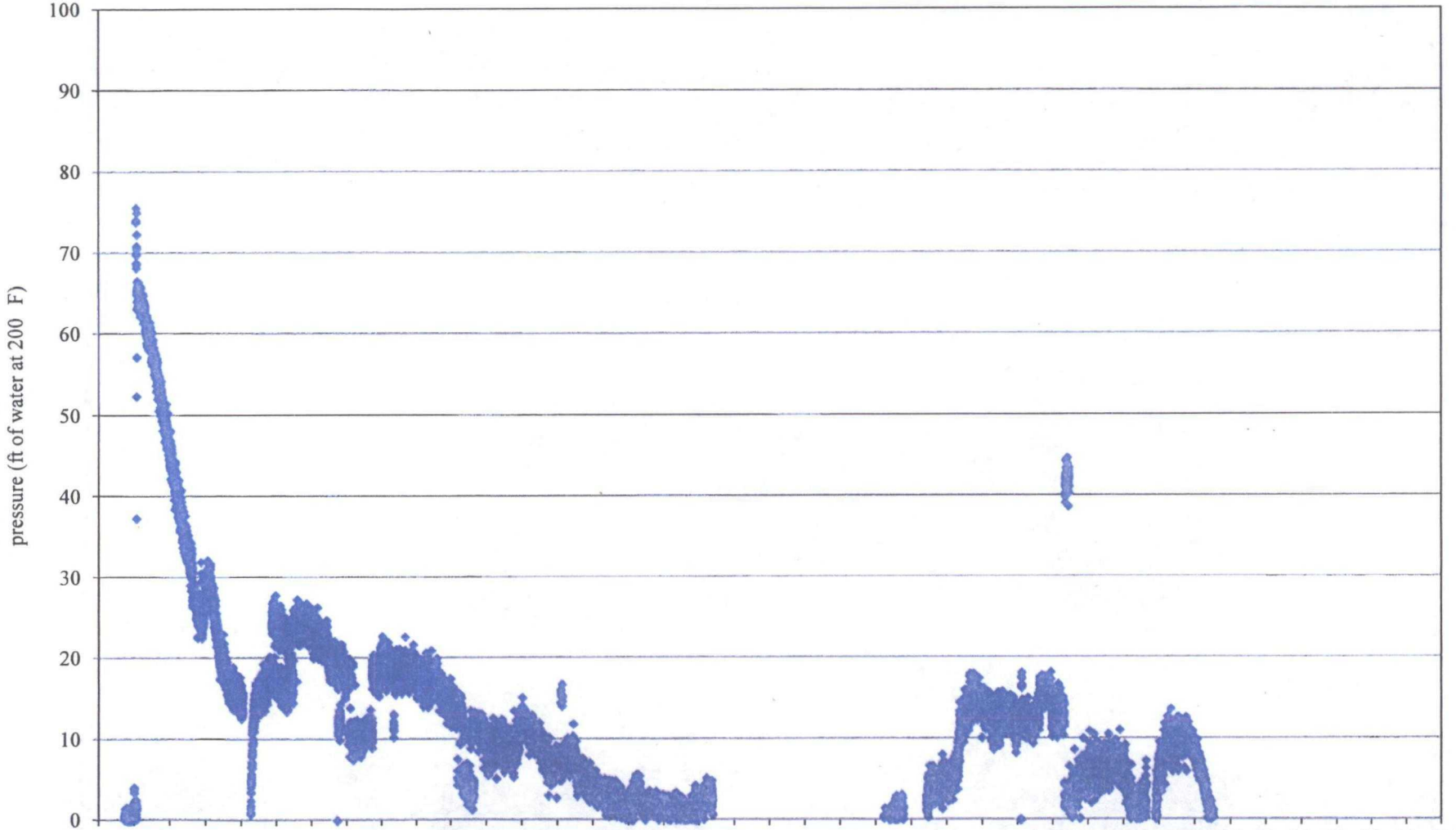

Figure 6. Injection pressure at wellhead, Well 55-7, feet of water at 200° F.

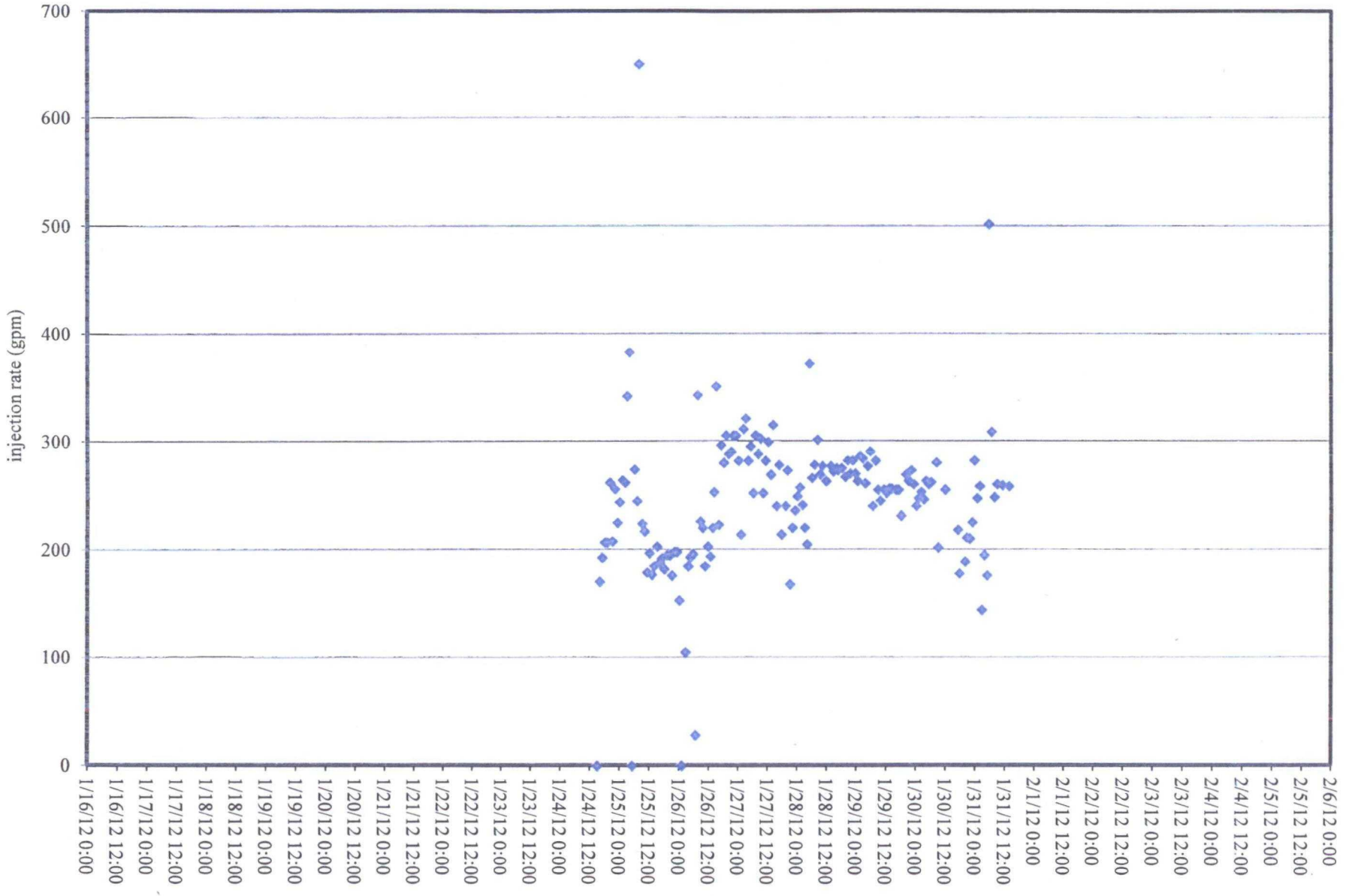

Figure 7. Injection rate, State No. 7 well during closed-loop test (water supplied off-site from fresh water source).

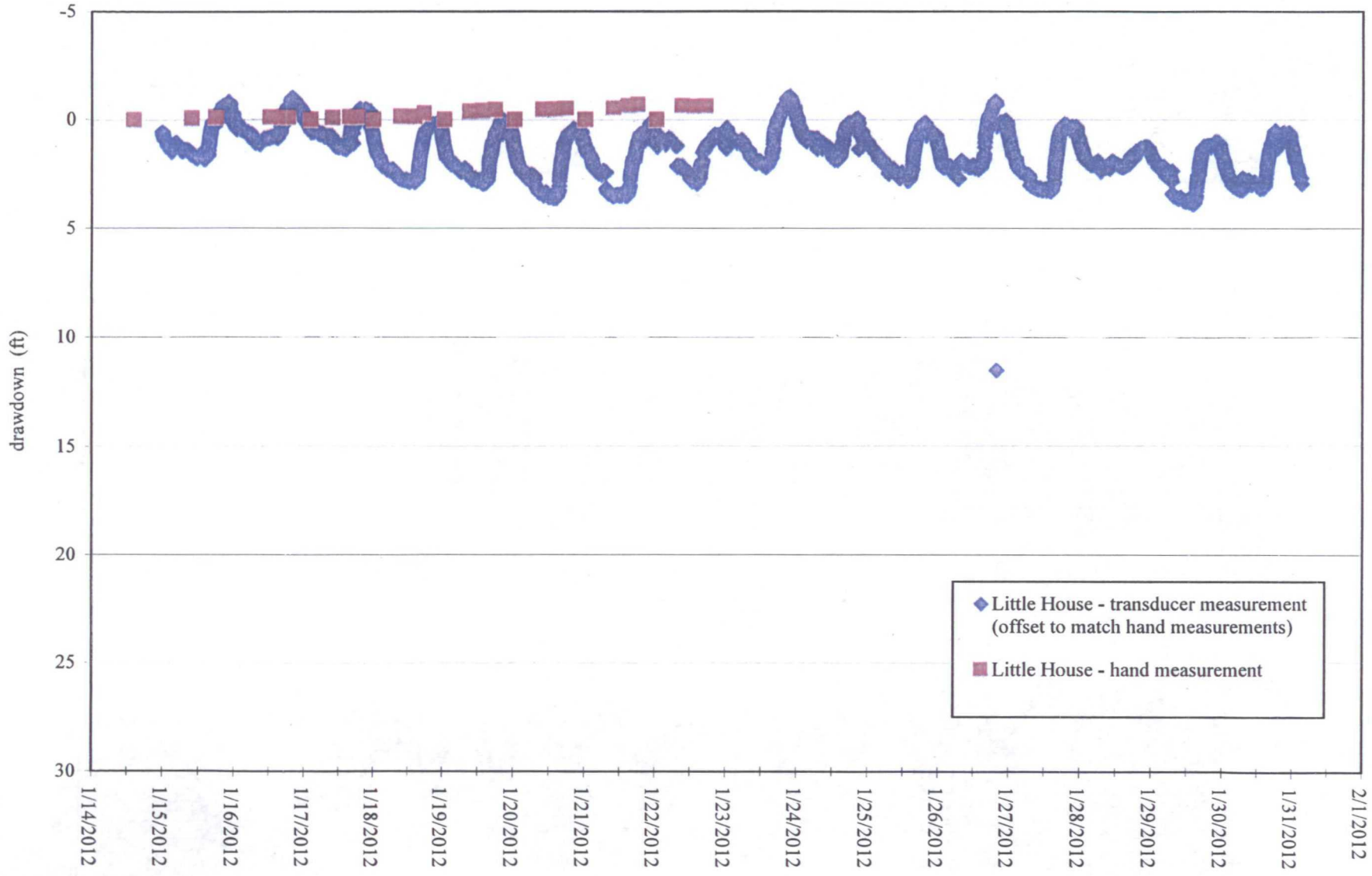

Figure 8. Drawdown in Little House Well during closed-loop test.

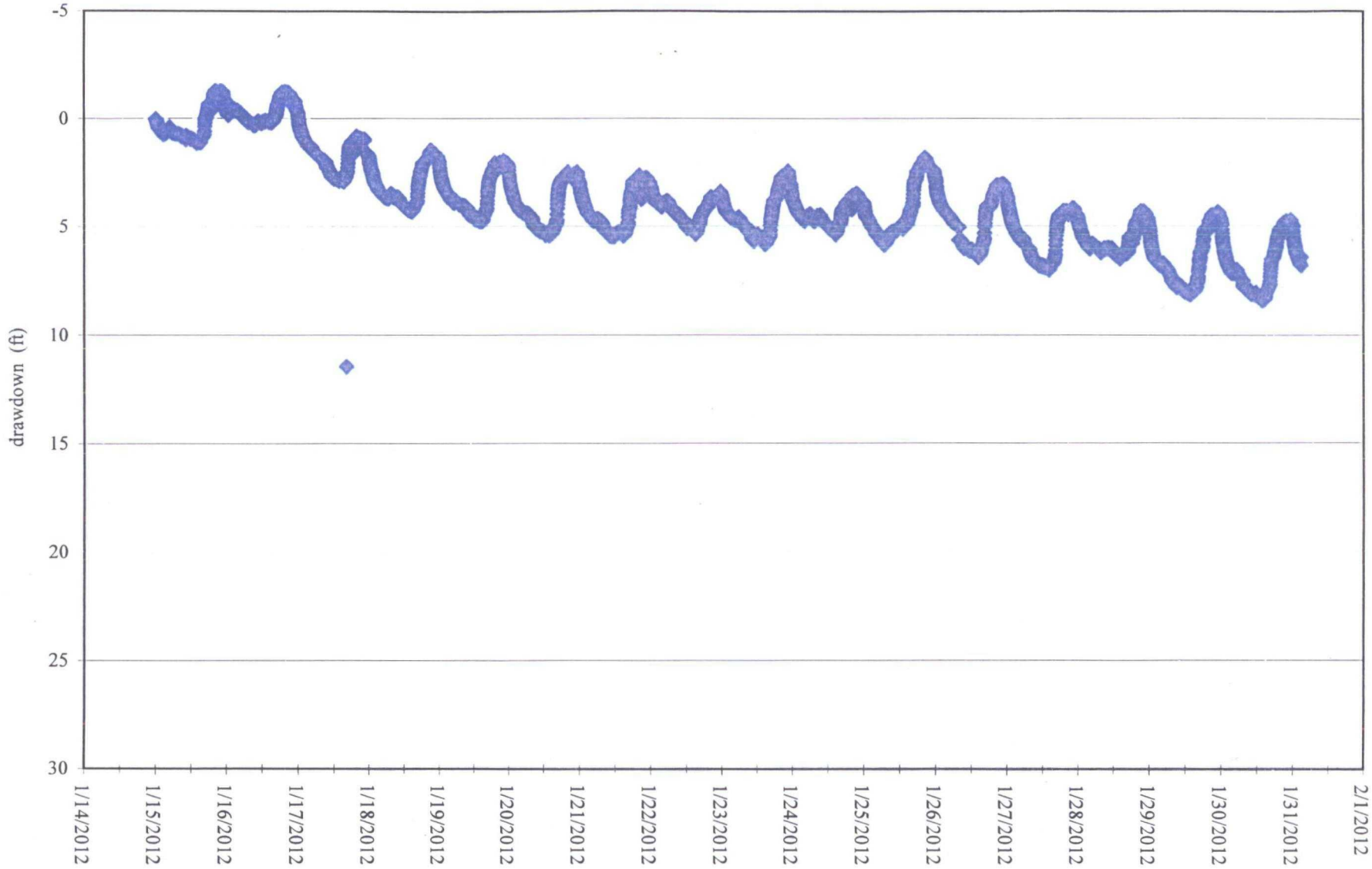

Figure 9. Drawdown in Well G-6-W during closed-loop test.

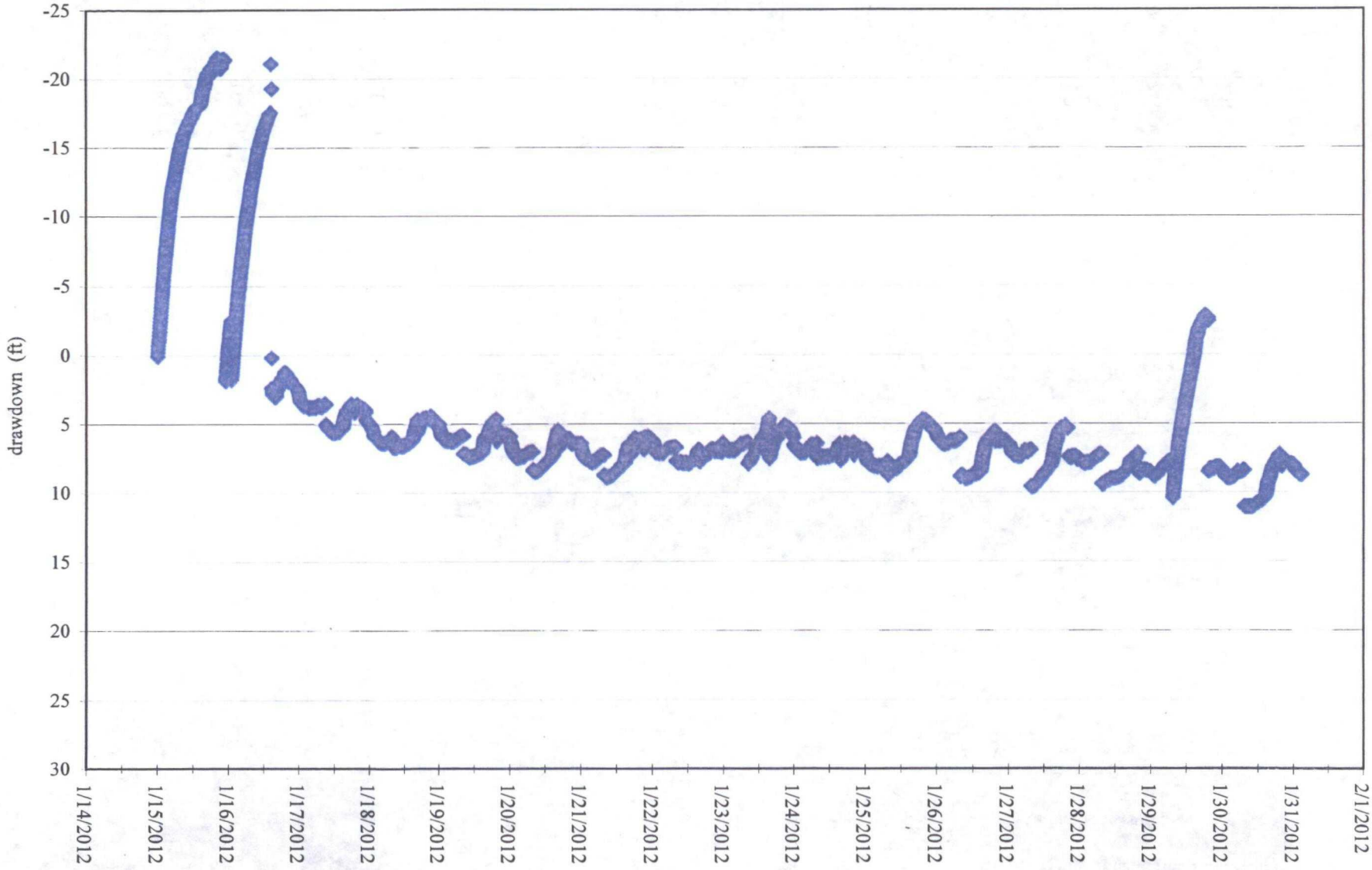

Figure 10. Drawdown in Well G-3-S during closed-loop test.

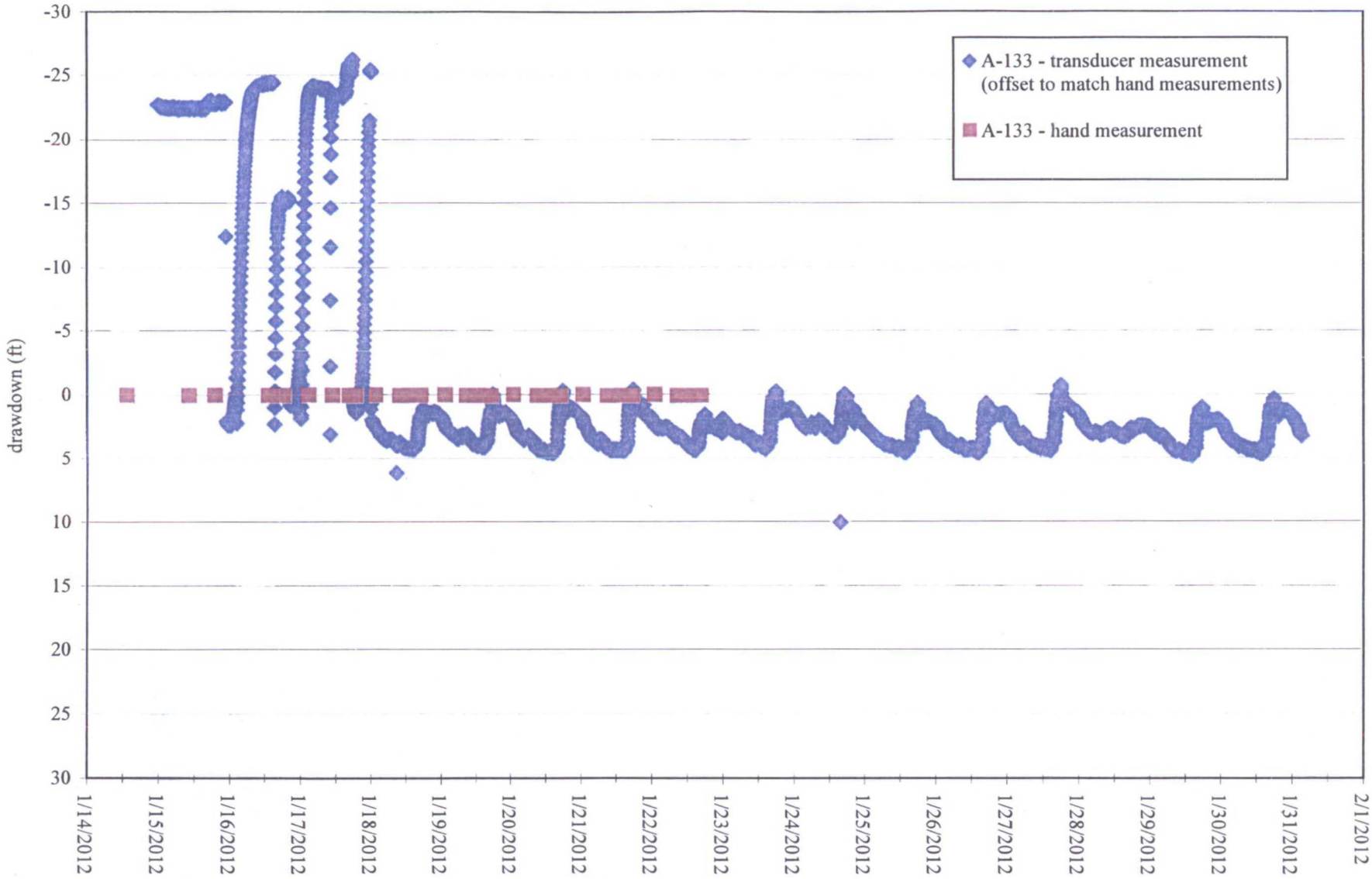

Figure 11. Drawdown in Well A-133 during closed-loop test.

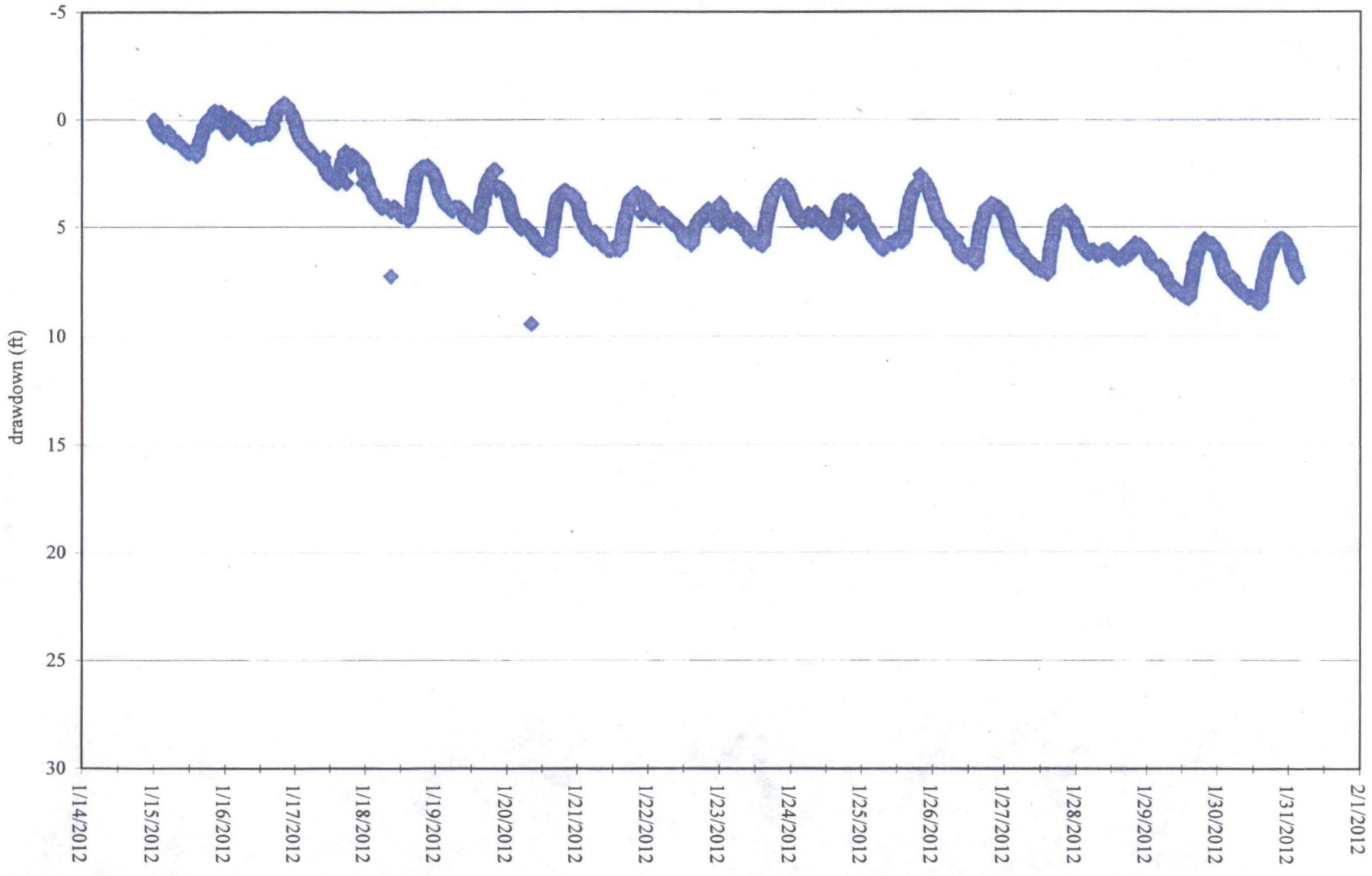

Figure 12. Drawdown in Well G-2-SE during closed-loop test.

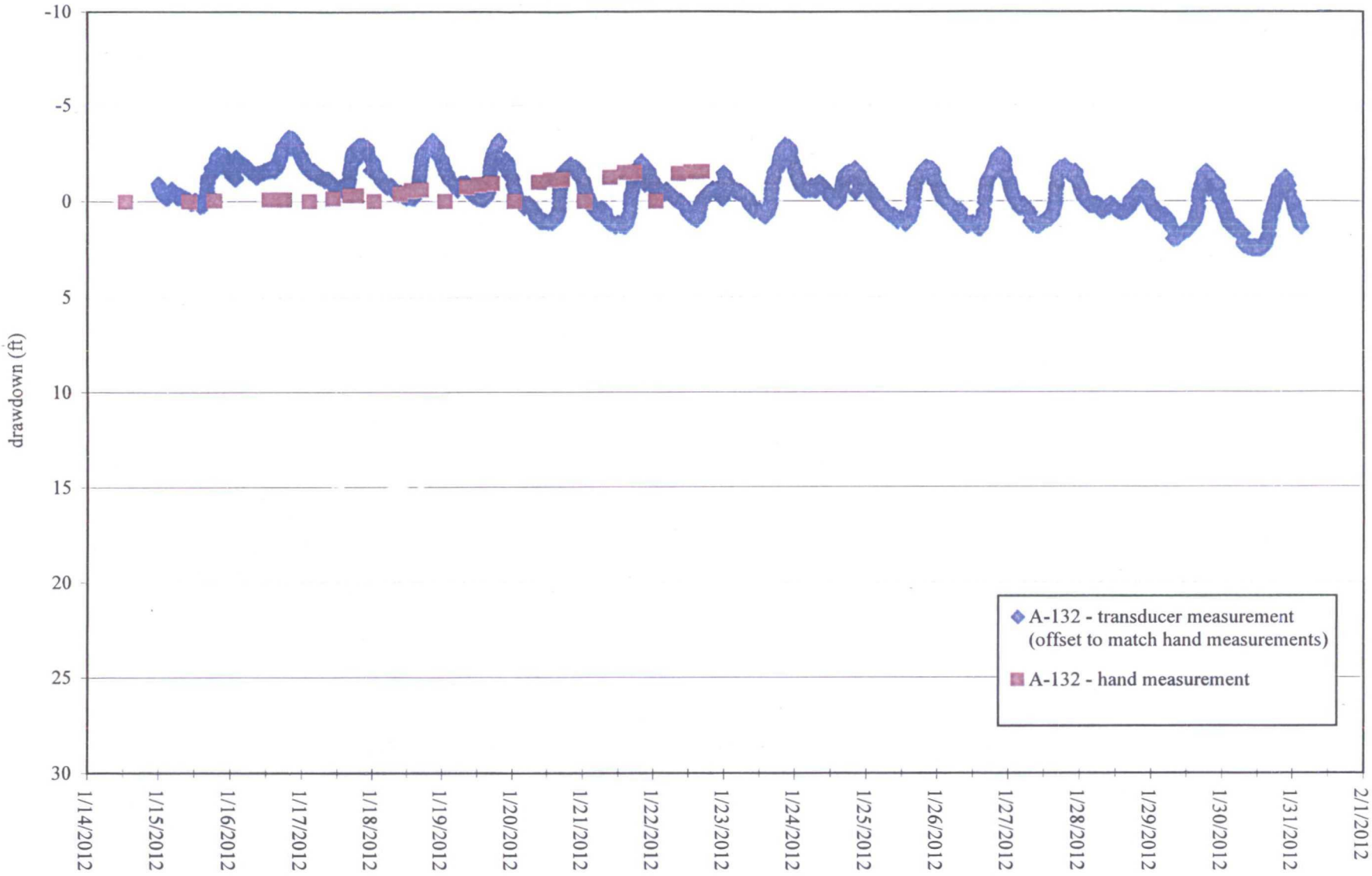

Figure 13. Drawdown in Well A-132 during closed-loop test.

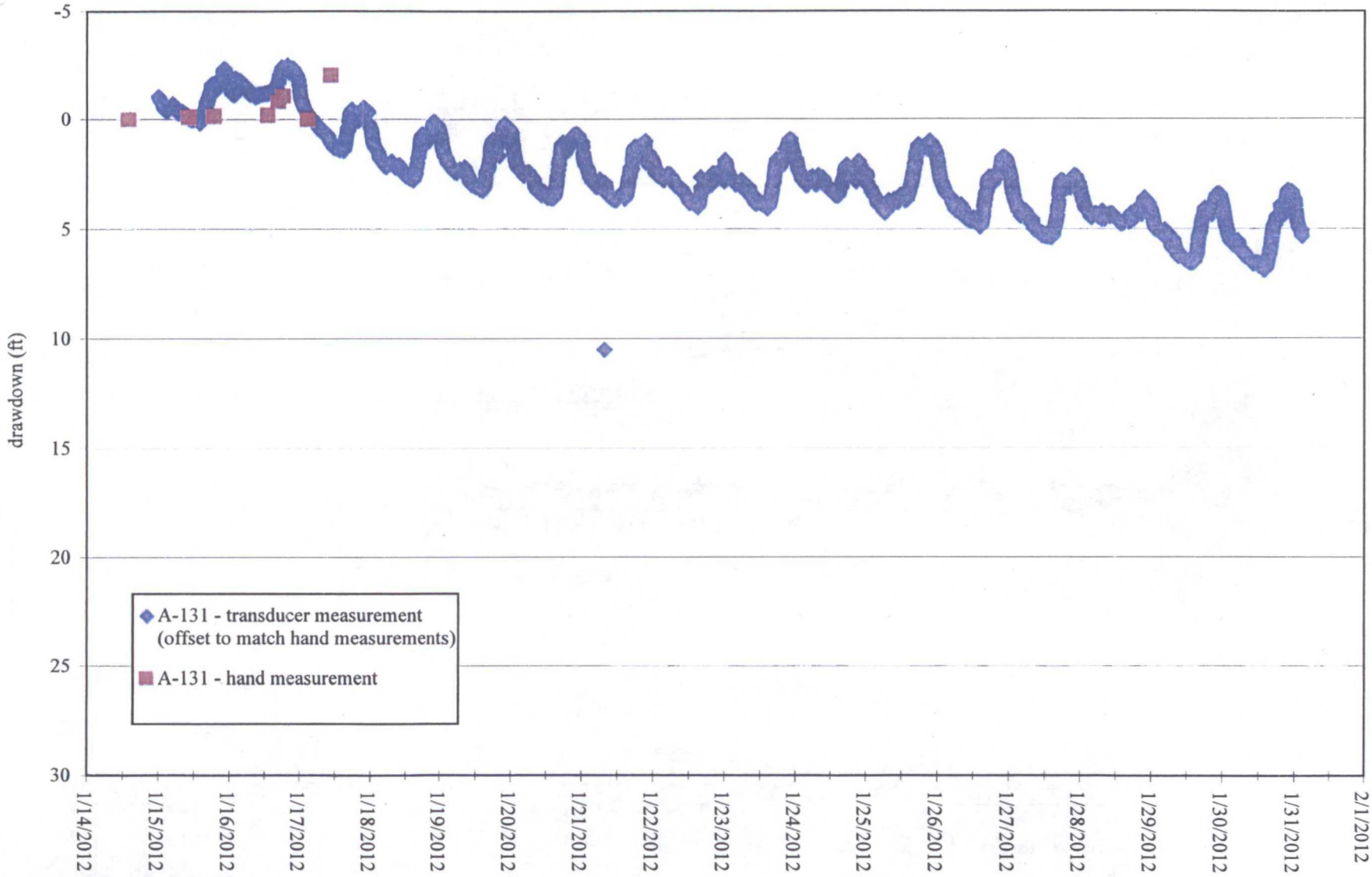

Figure 14. Drawdown in Well A-131 during closed-loop test.

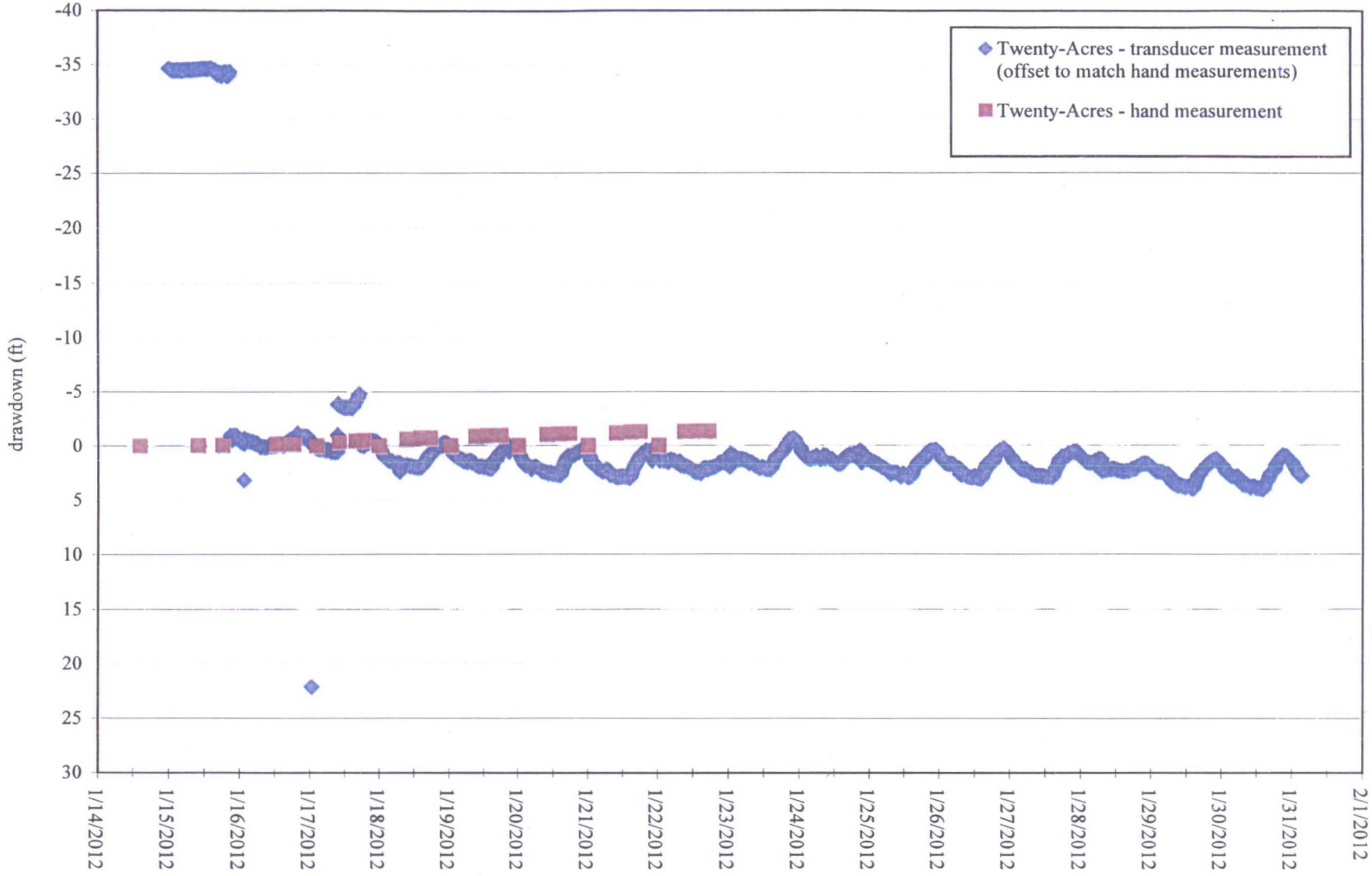

Figure 15. Drawdown in Twenty-Acres Well during closed-loop test.

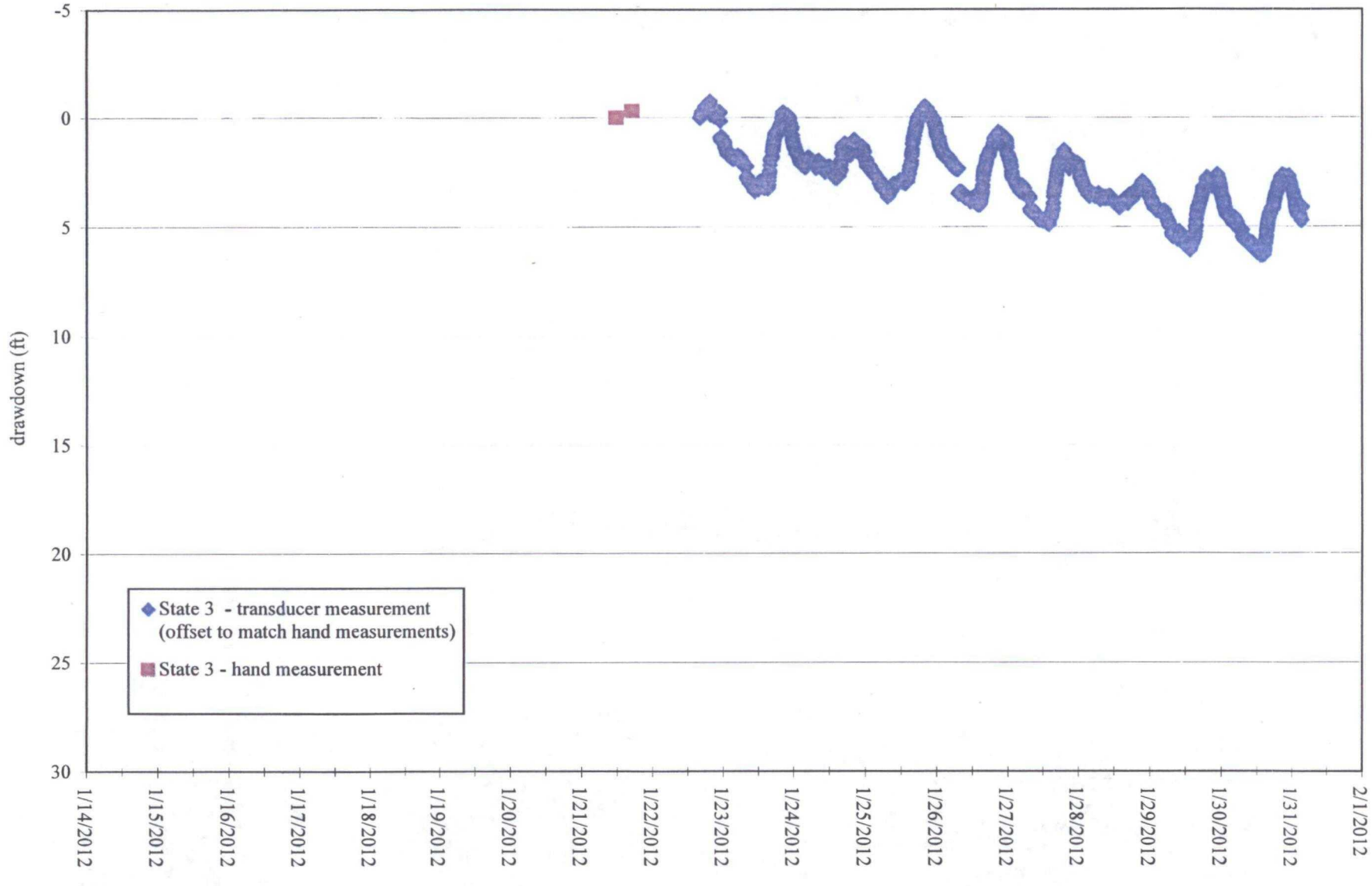

Figure 16. Drawdown in State No. 3 Well during closed-loop test.

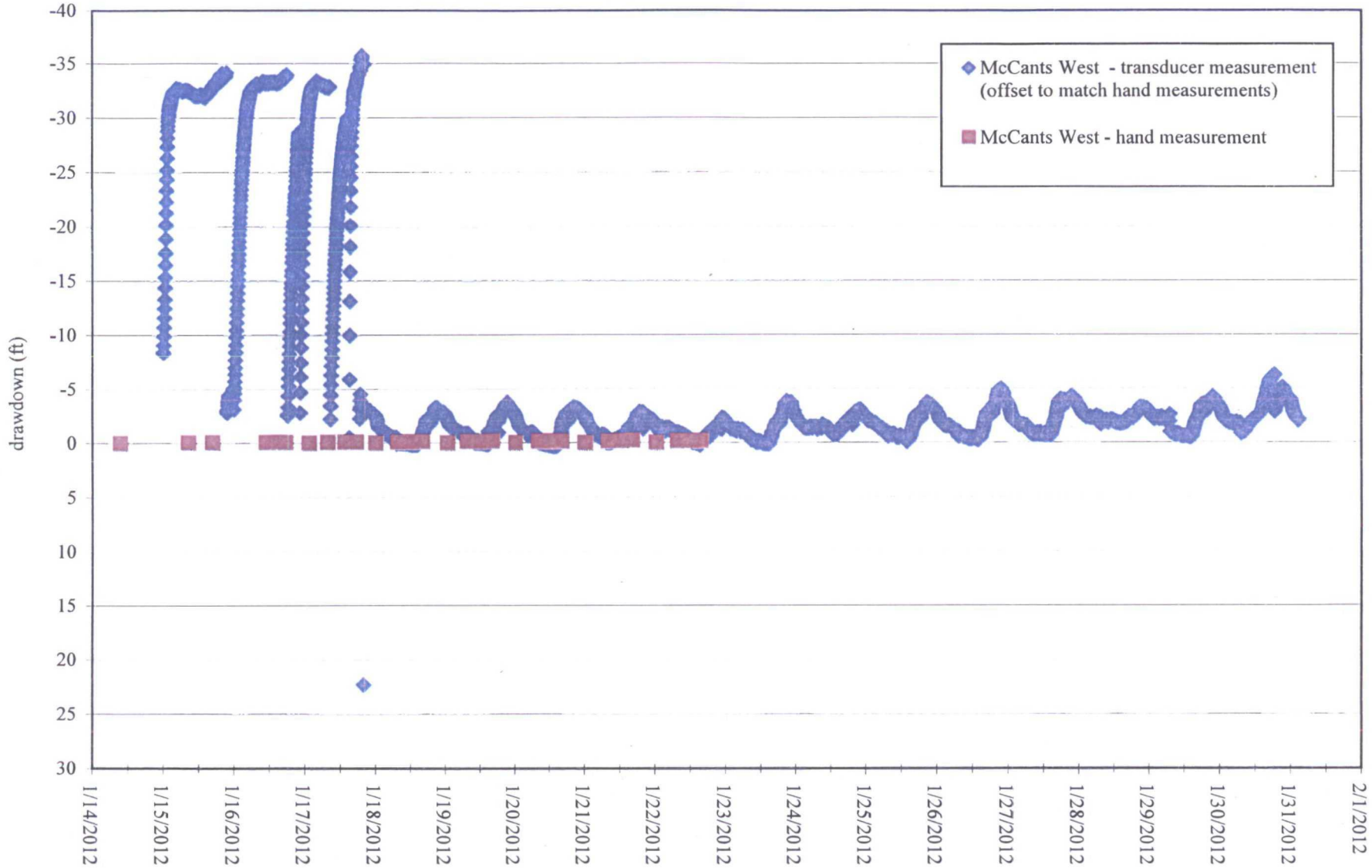

Figure 17. Drawdown in McCants West Well during closed-loop test.

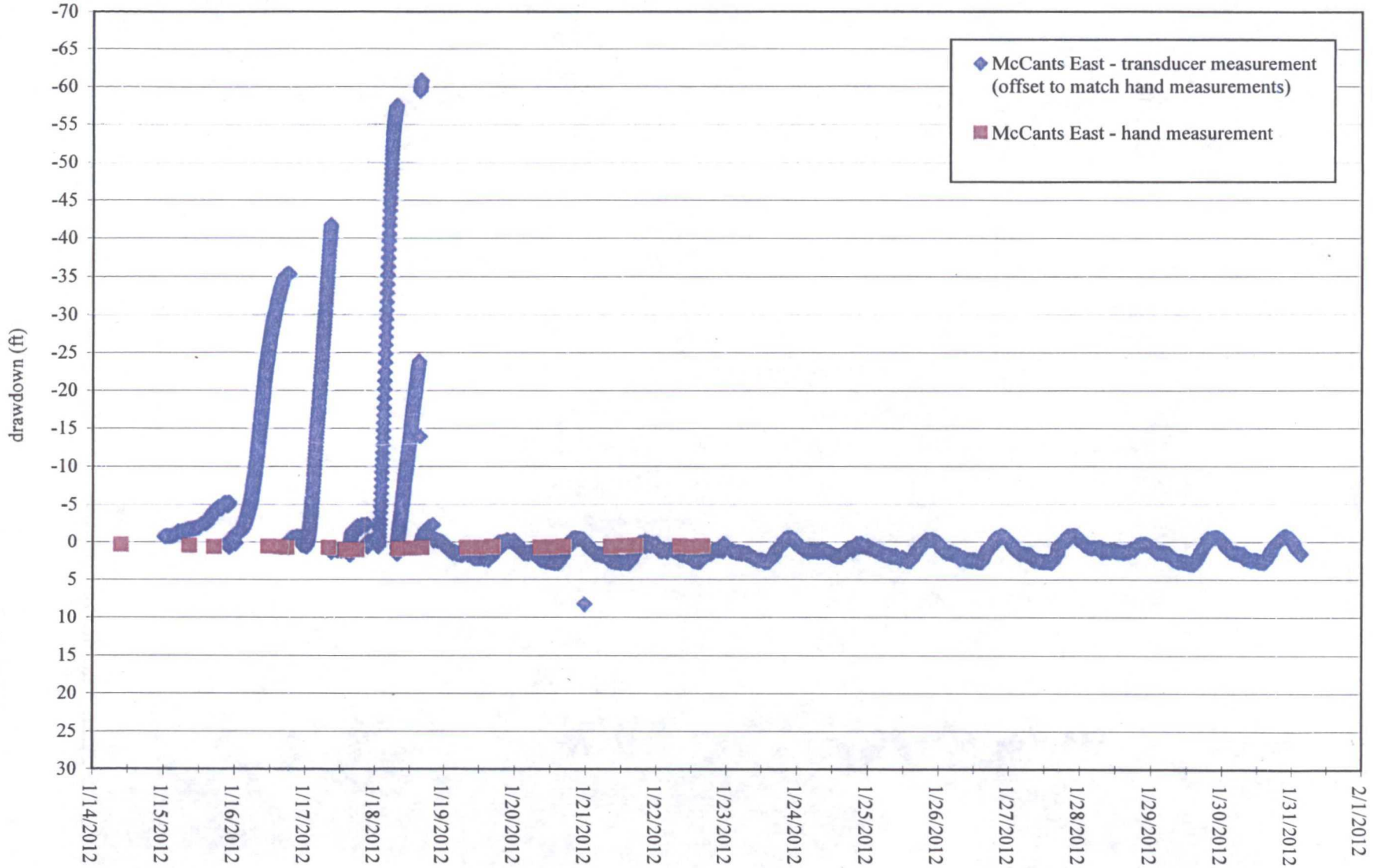

Figure 18. Drawdown in McCants East Well during closed-loop test.

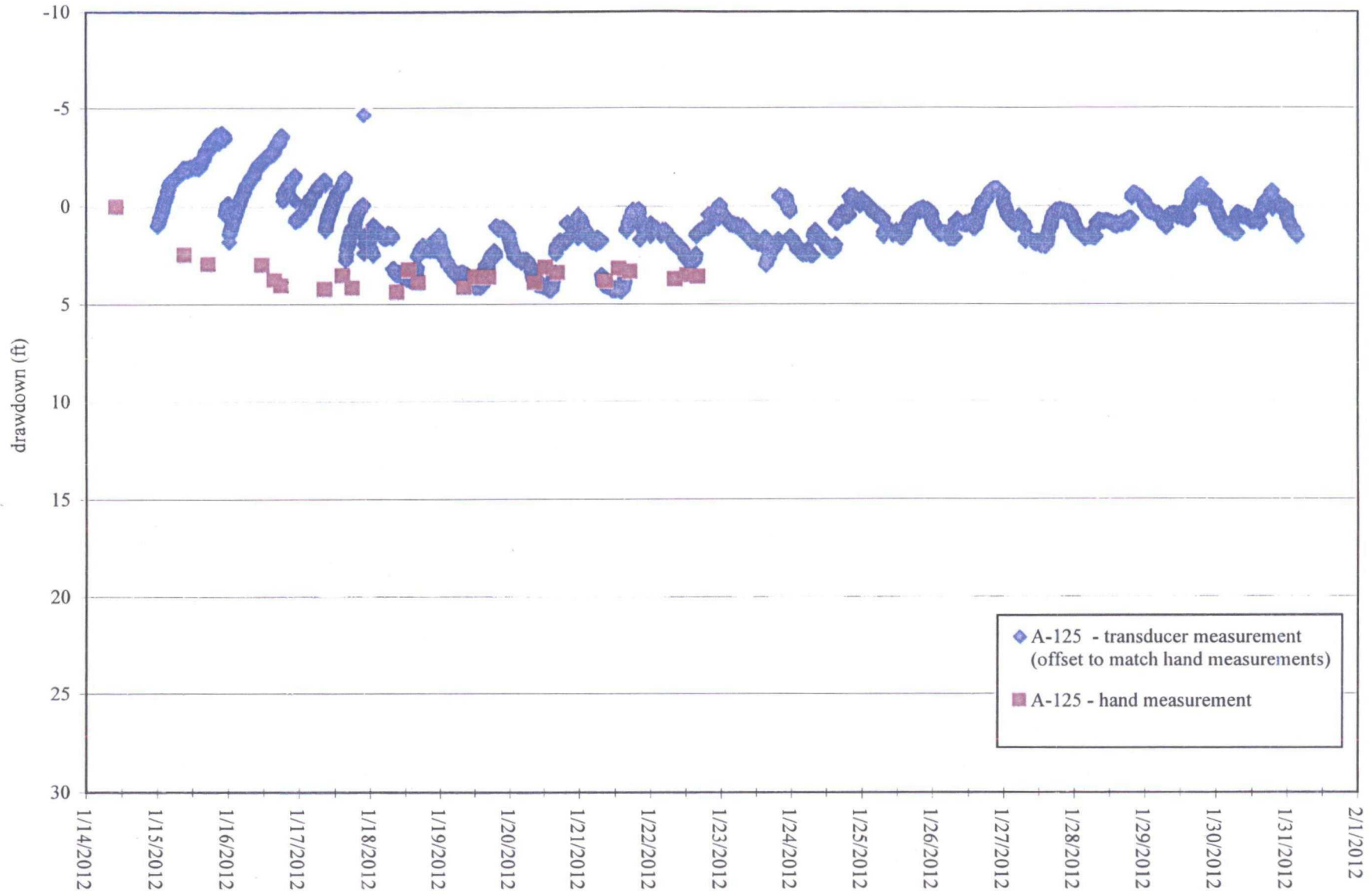

Figure 19. Drawdown in Well A-125 during closed-loop test.

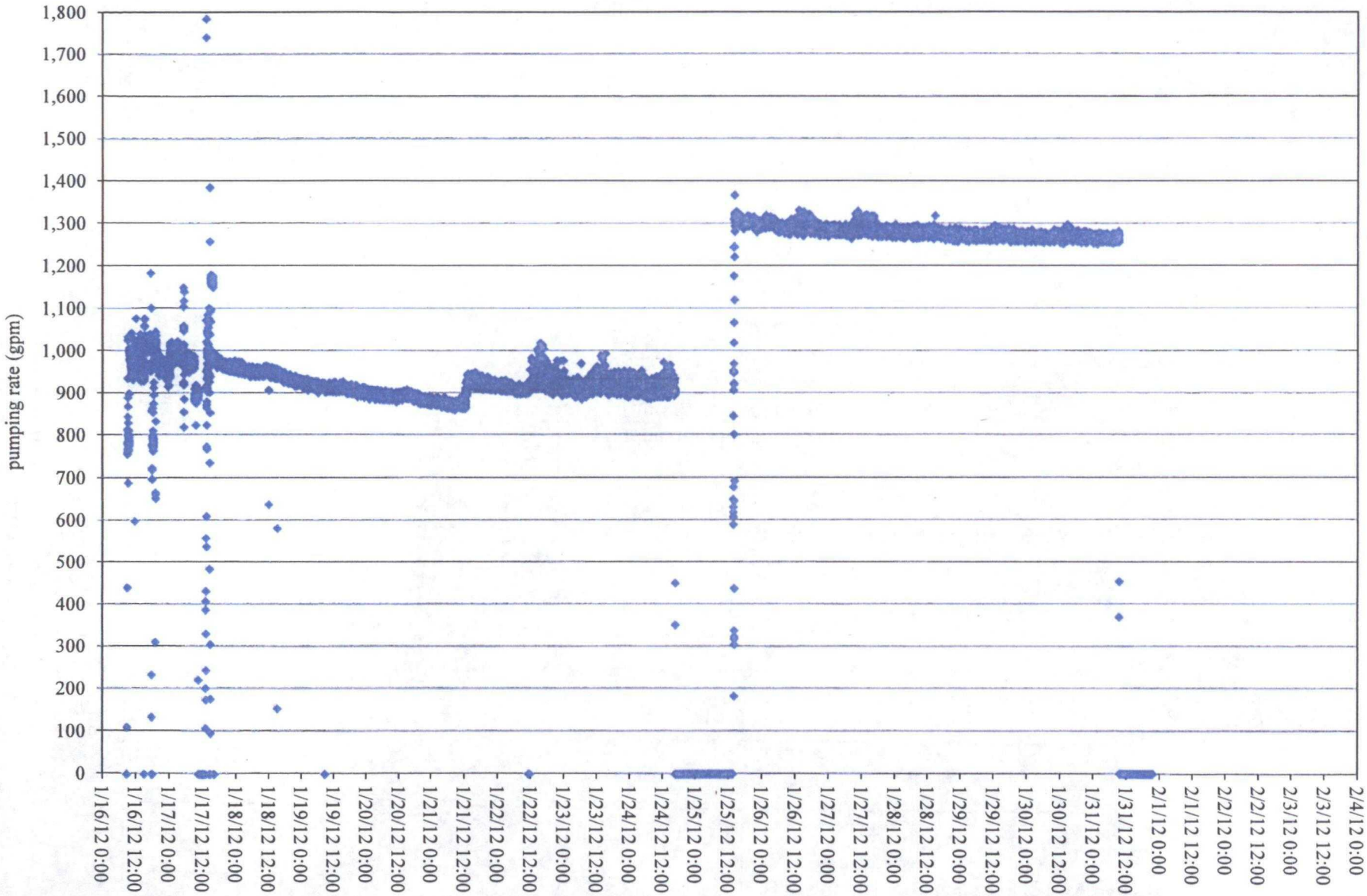

Figure 2. Pumping rate, Well 45-7 (measured by differential pressure at orifice plate).

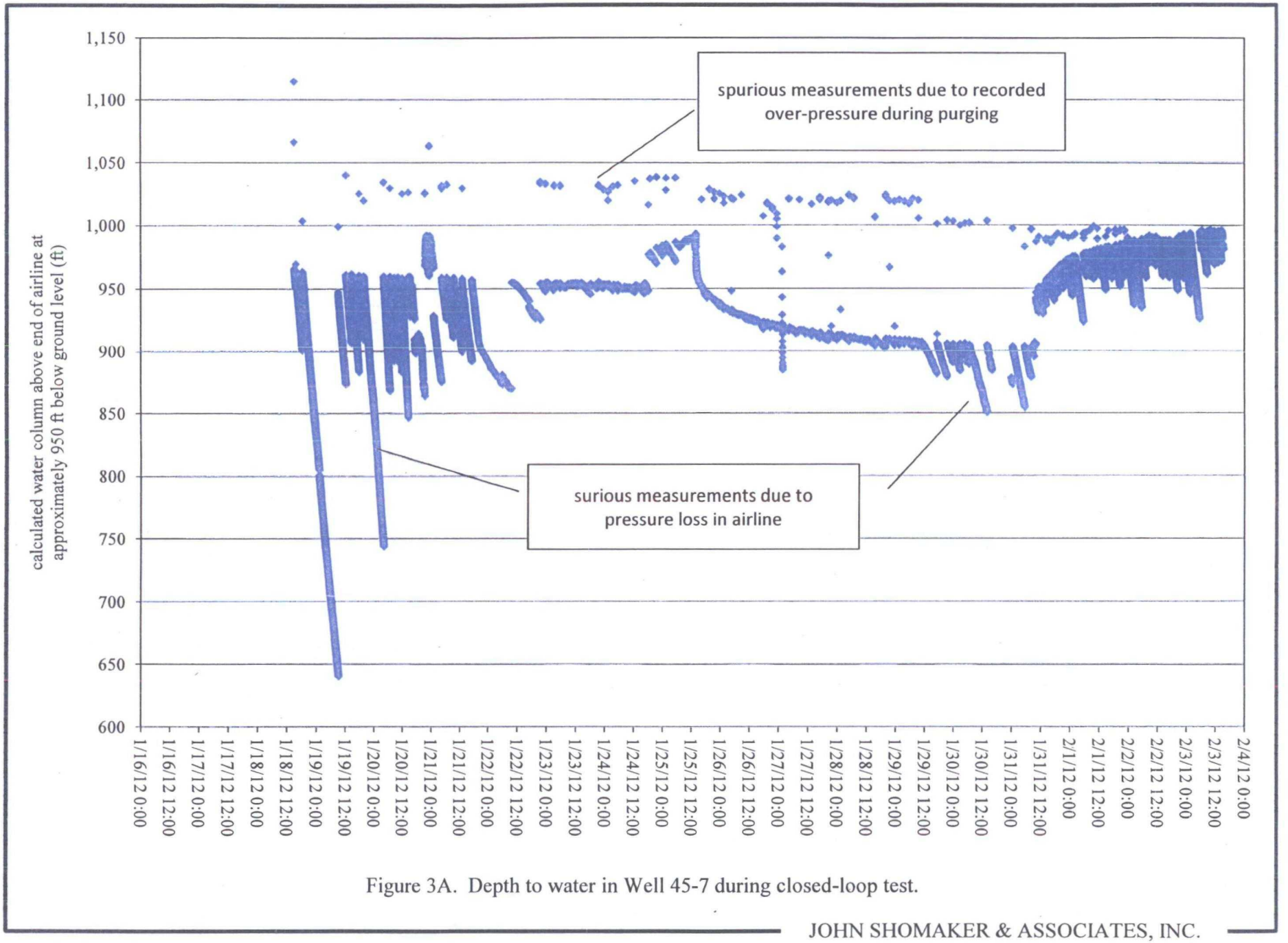

Figure 3A. Depth to water in Well 45-7 during closed-loop test.

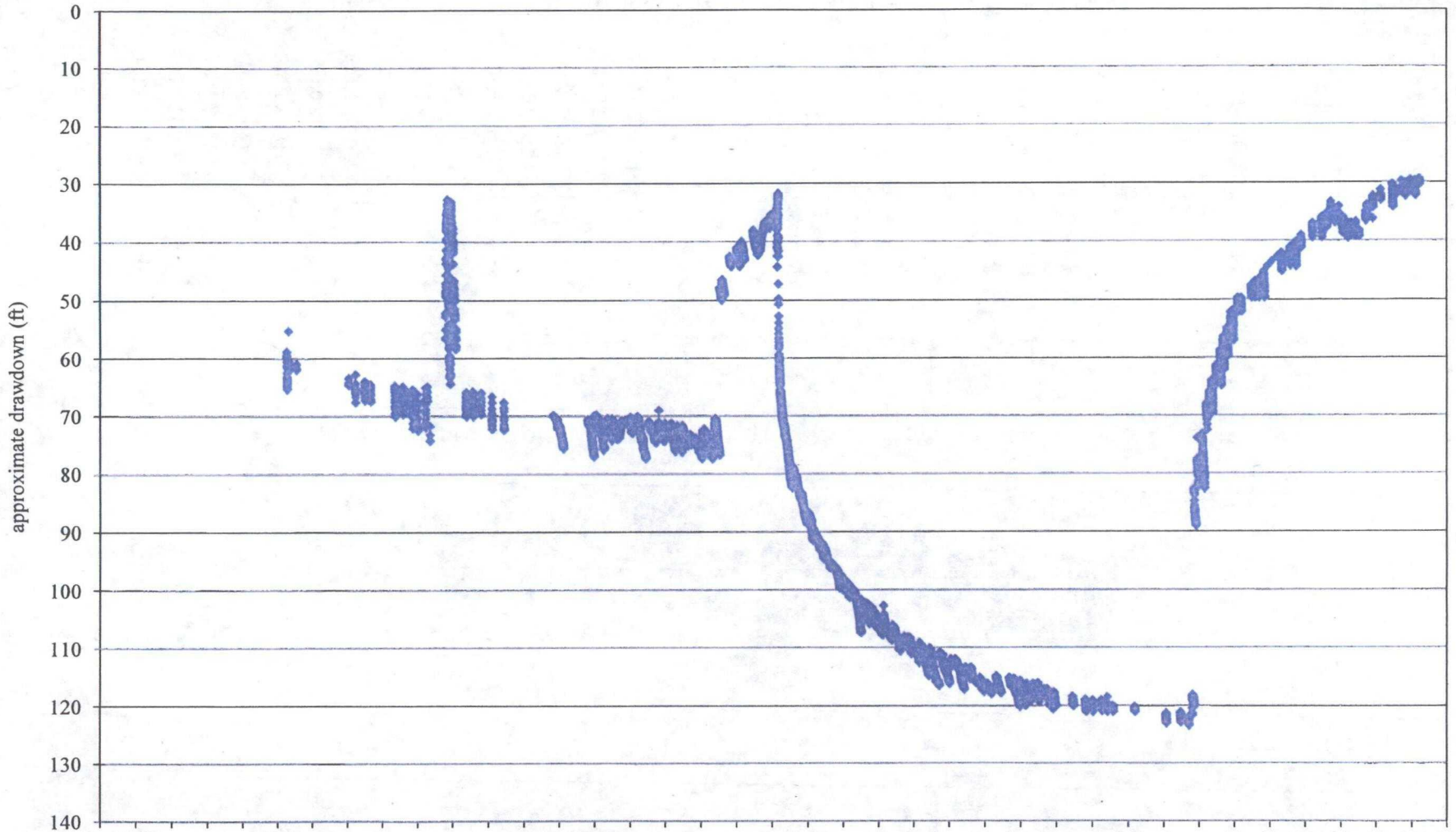

Figure 3B. Approximate drawdown in Well 45-7 during closed-loop test.

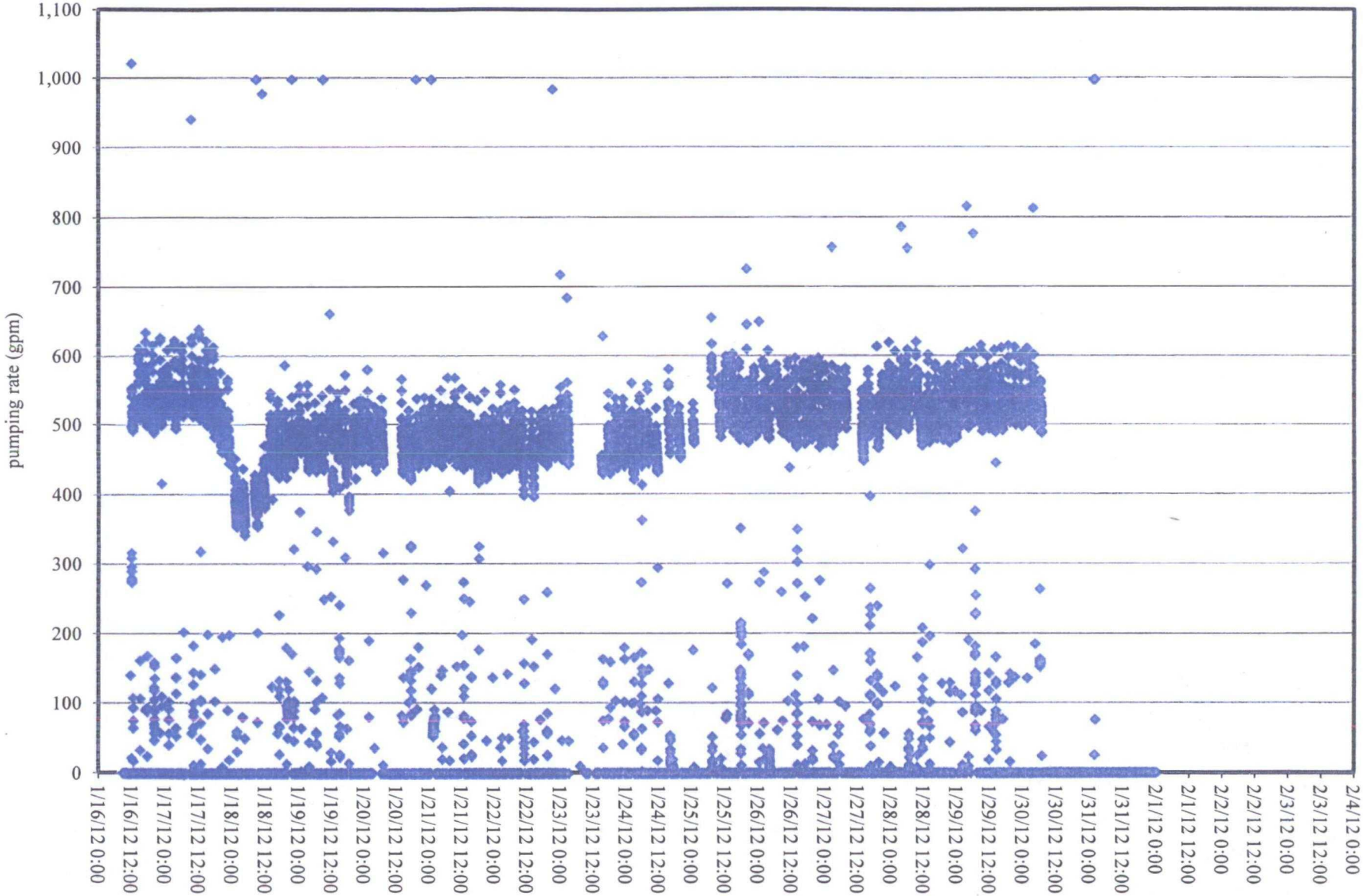

Figure 4. Pumping rate, Well 53-7 (flow rate through pipe after storage tank).

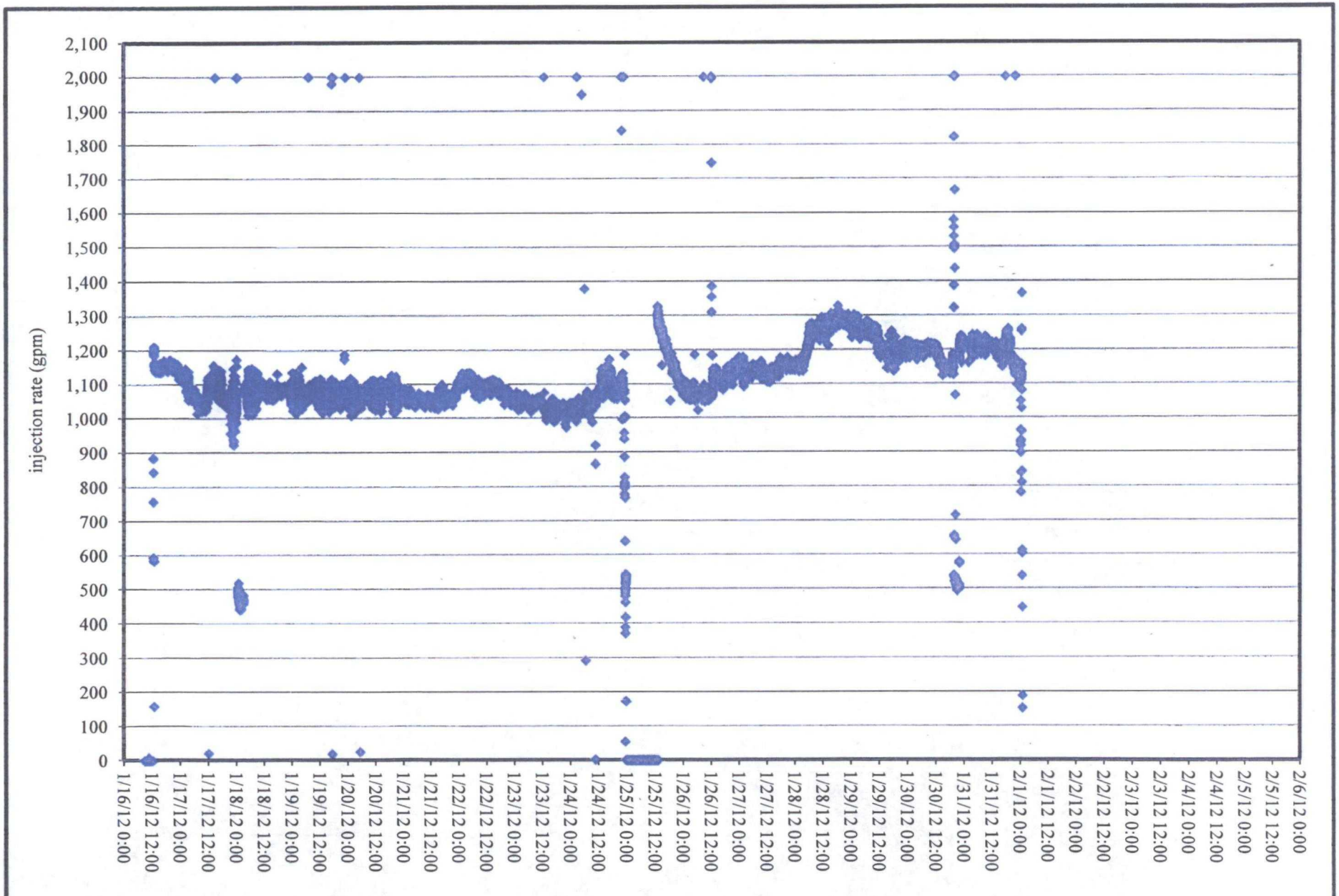

Figure 5. Injection rate, Well 55-7.

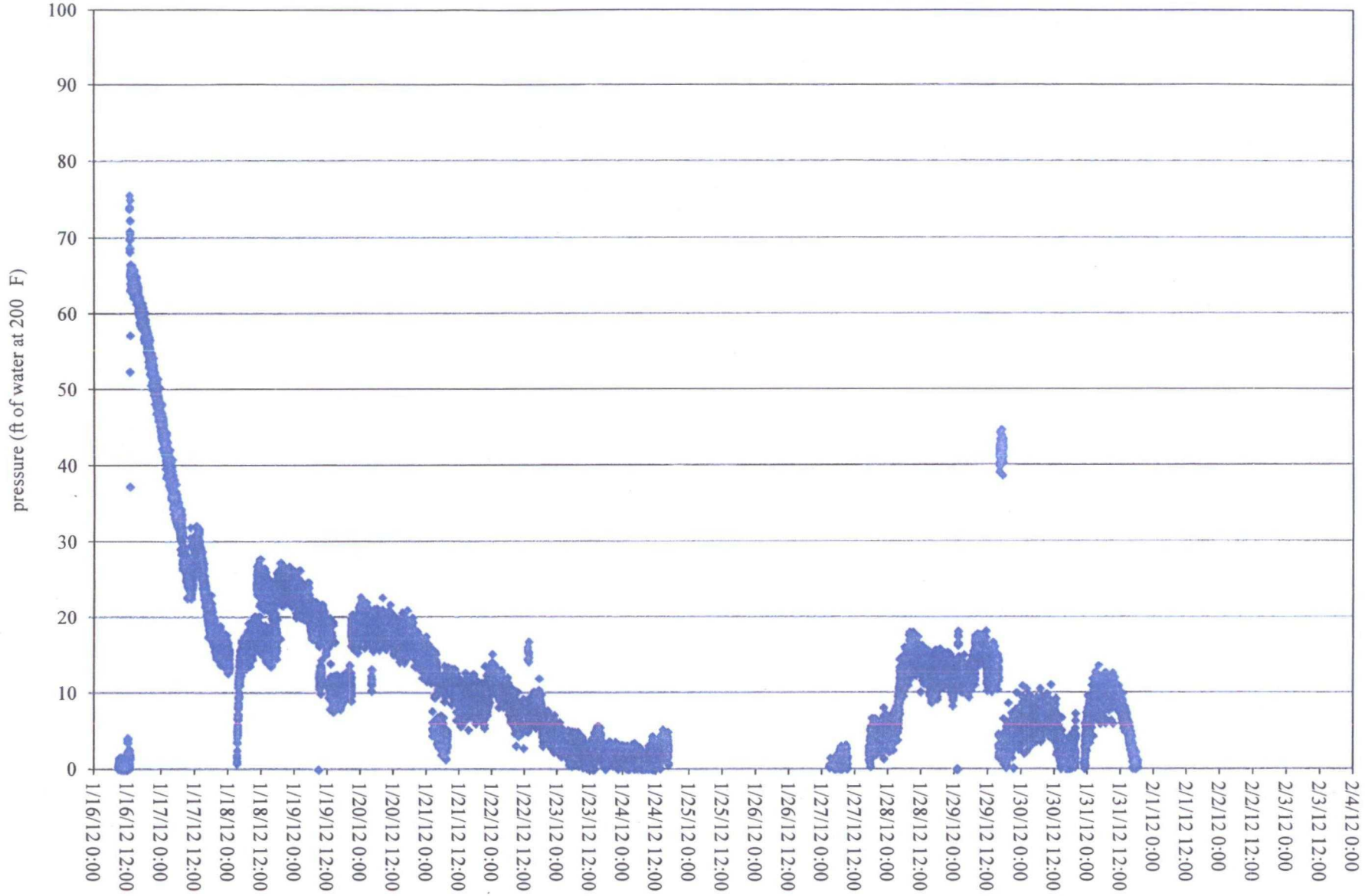

Figure 6. Injection pressure at wellhead, Well 55-7, feet of water at 200° F.

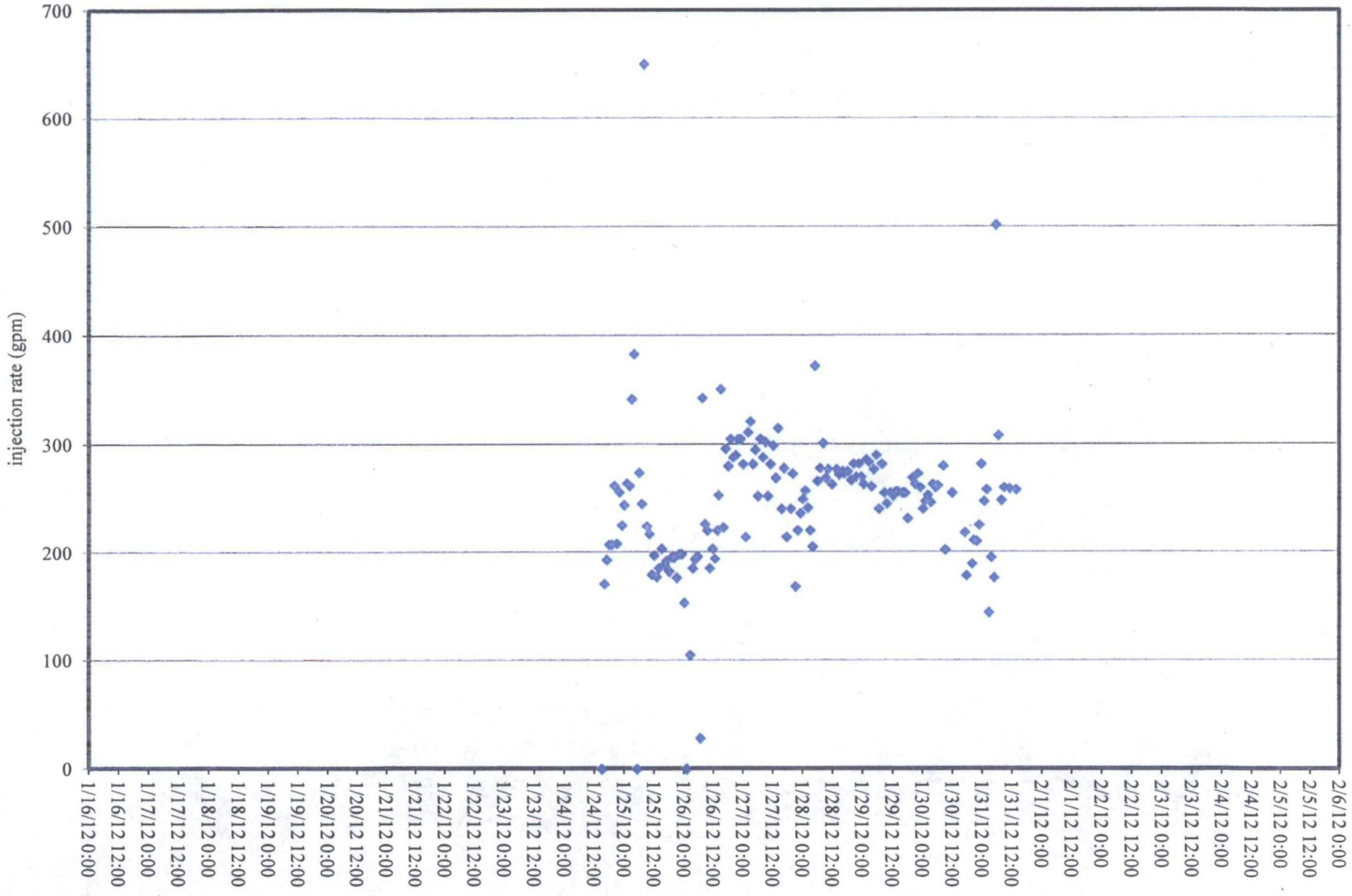

Figure 7. Injection rate, State No. 7 well during closed-loop test (water supplied off-site from fresh water source).

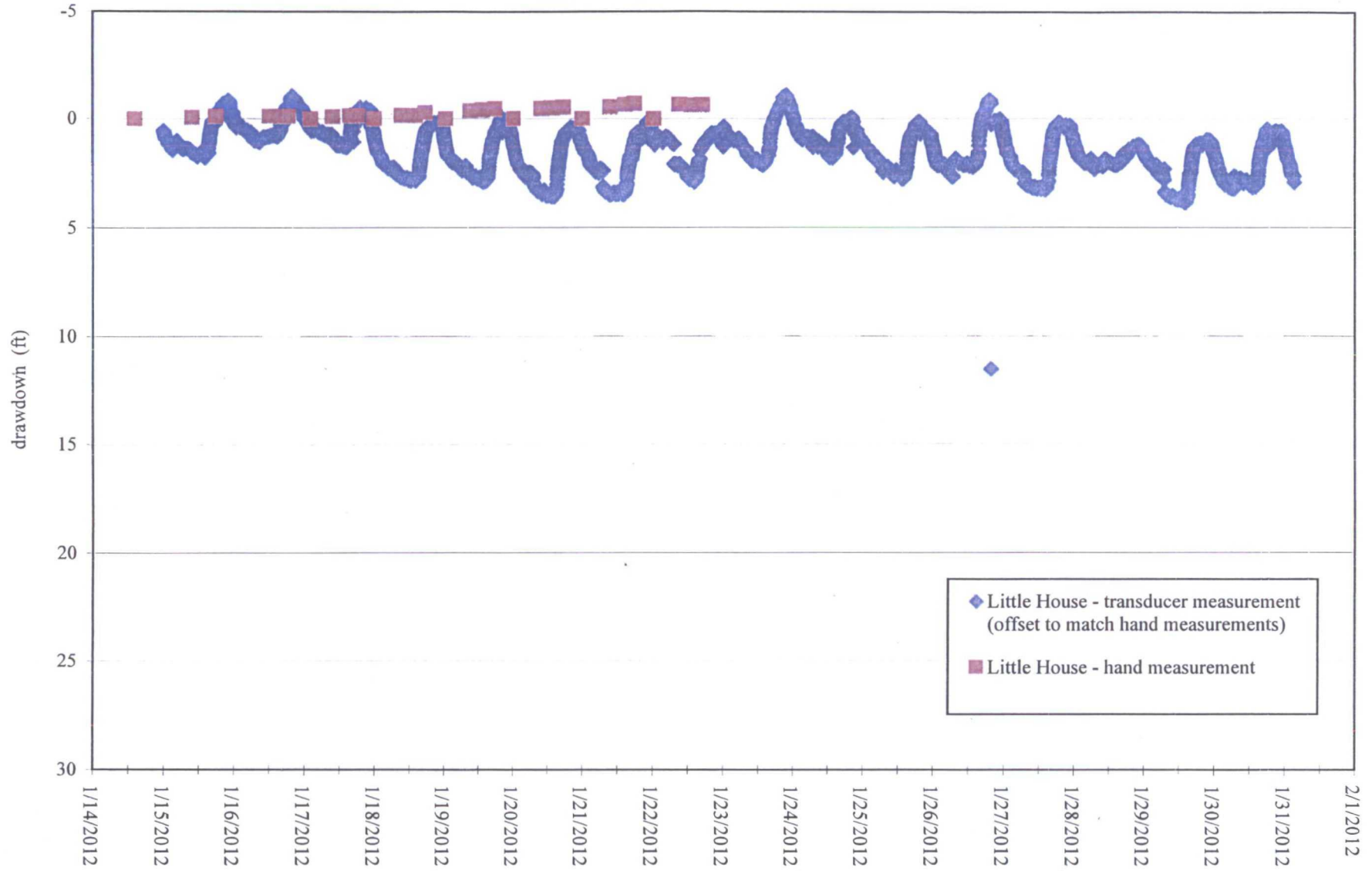

Figure 8. Drawdown in Little House Well during closed-loop test.

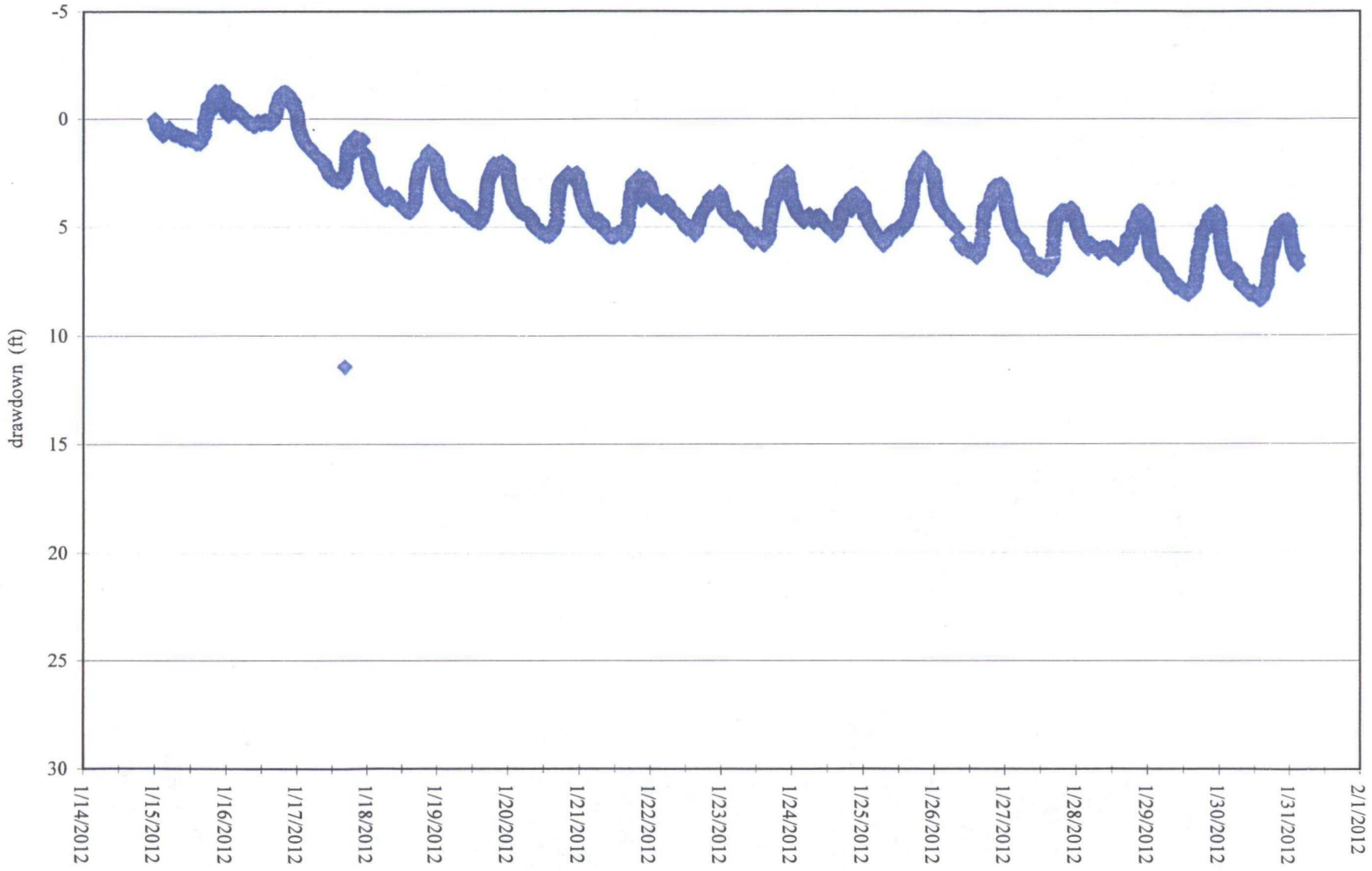

Figure 9. Drawdown in Well G-6-W during closed-loop test.

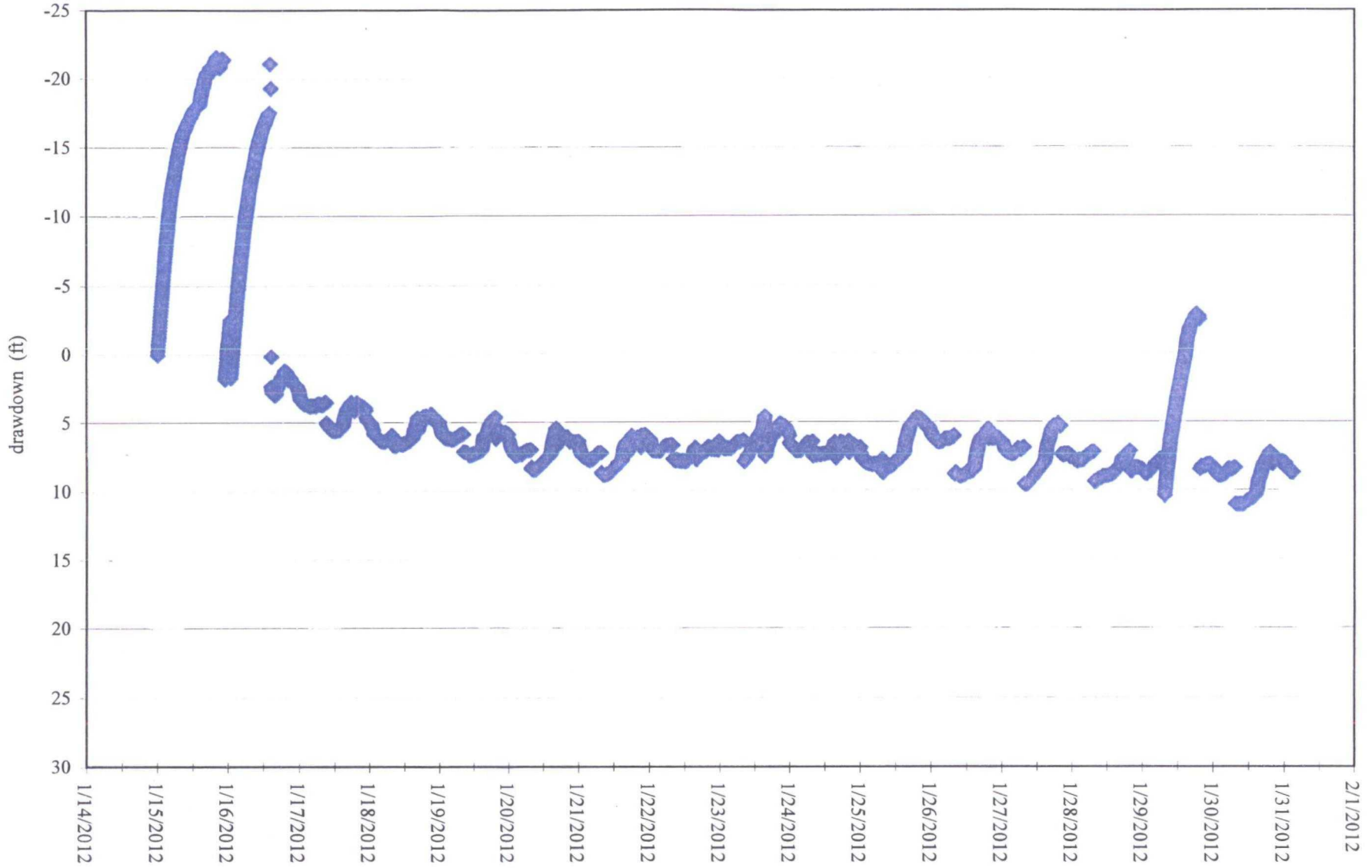

Figure 10. Drawdown in Well G-3-S during closed-loop test.

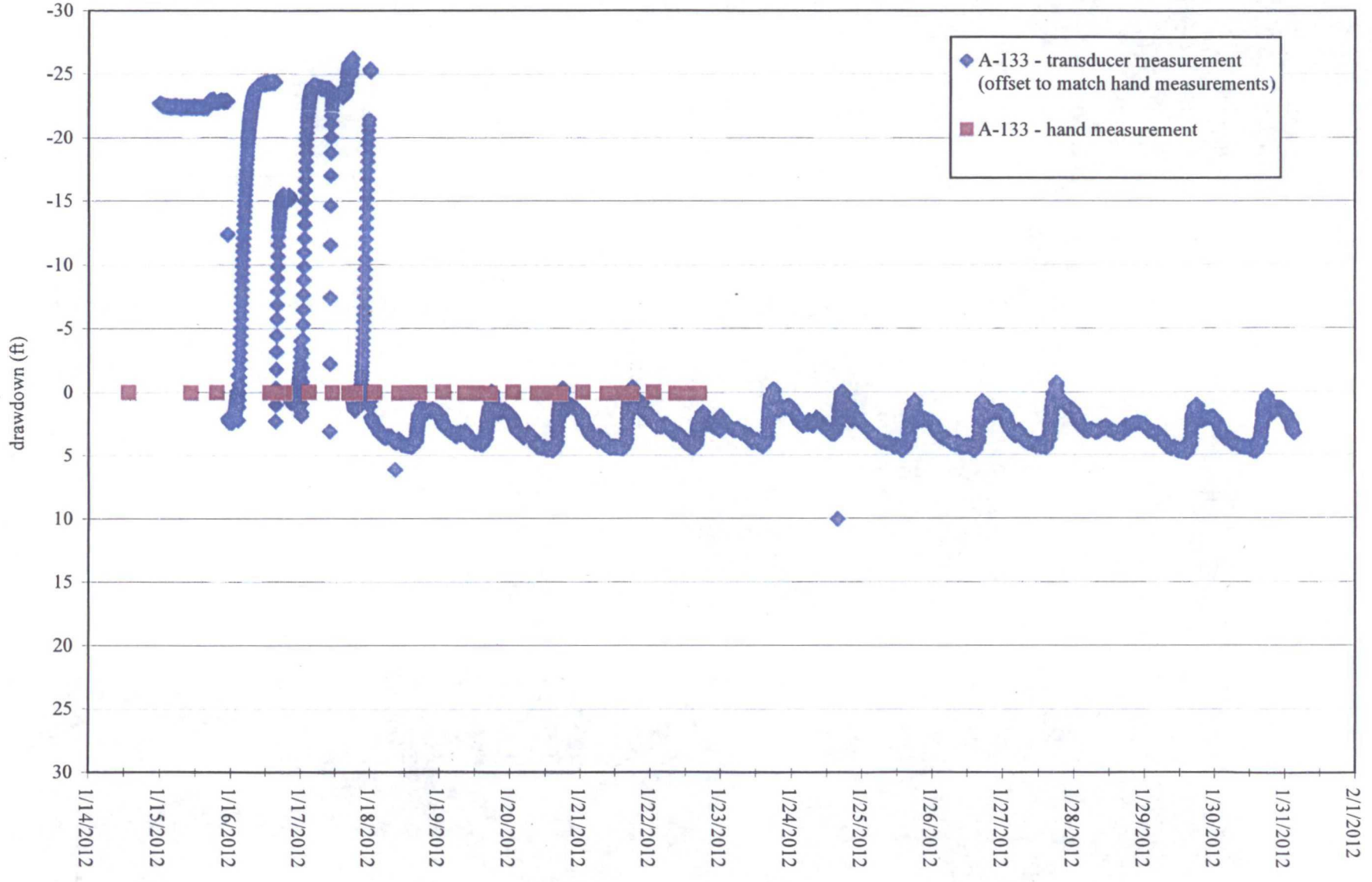

Figure 11. Drawdown in Well A-133 during closed-loop test.

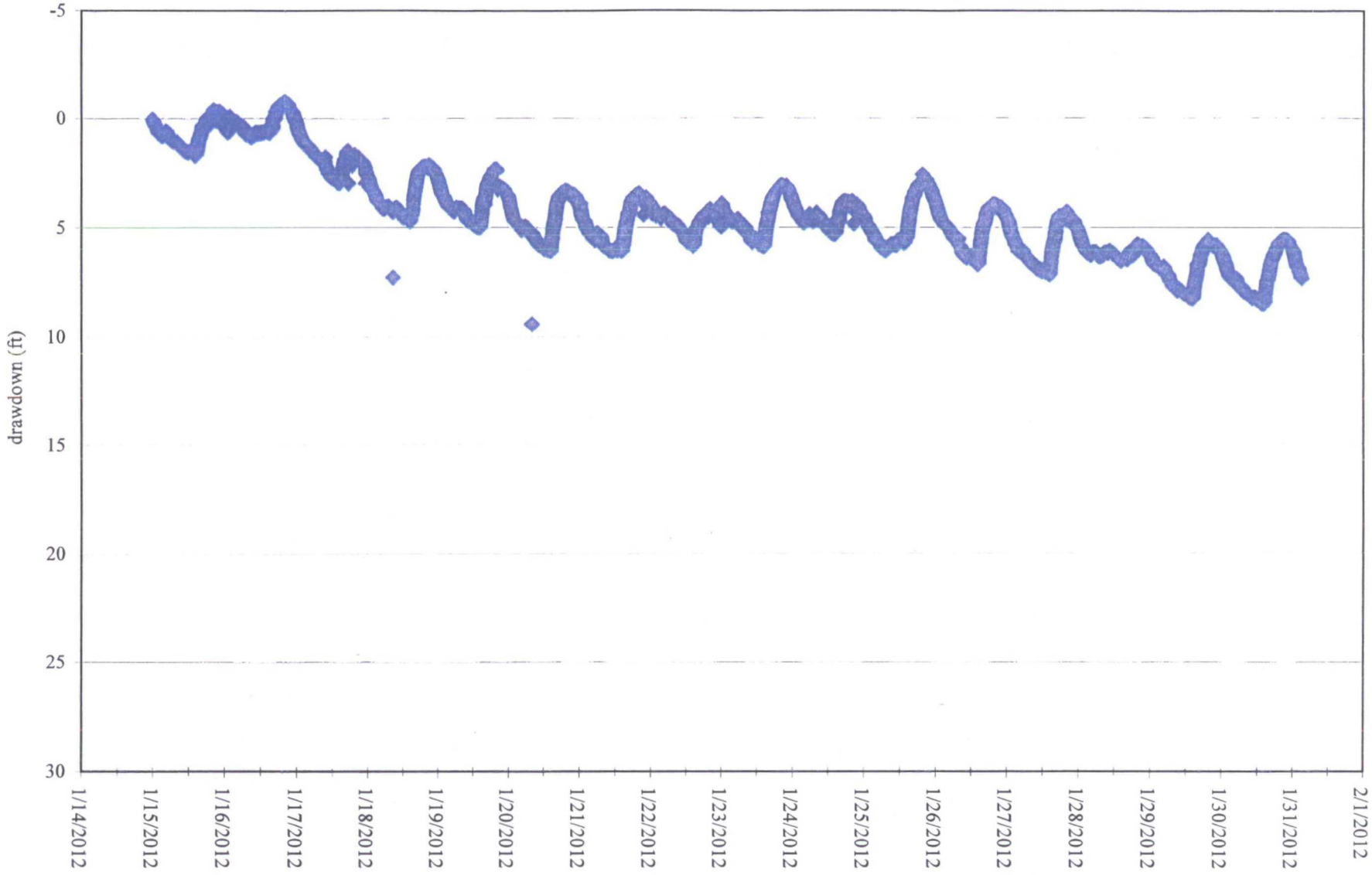

Figure 12. Drawdown in Well G-2-SE during closed-loop test.

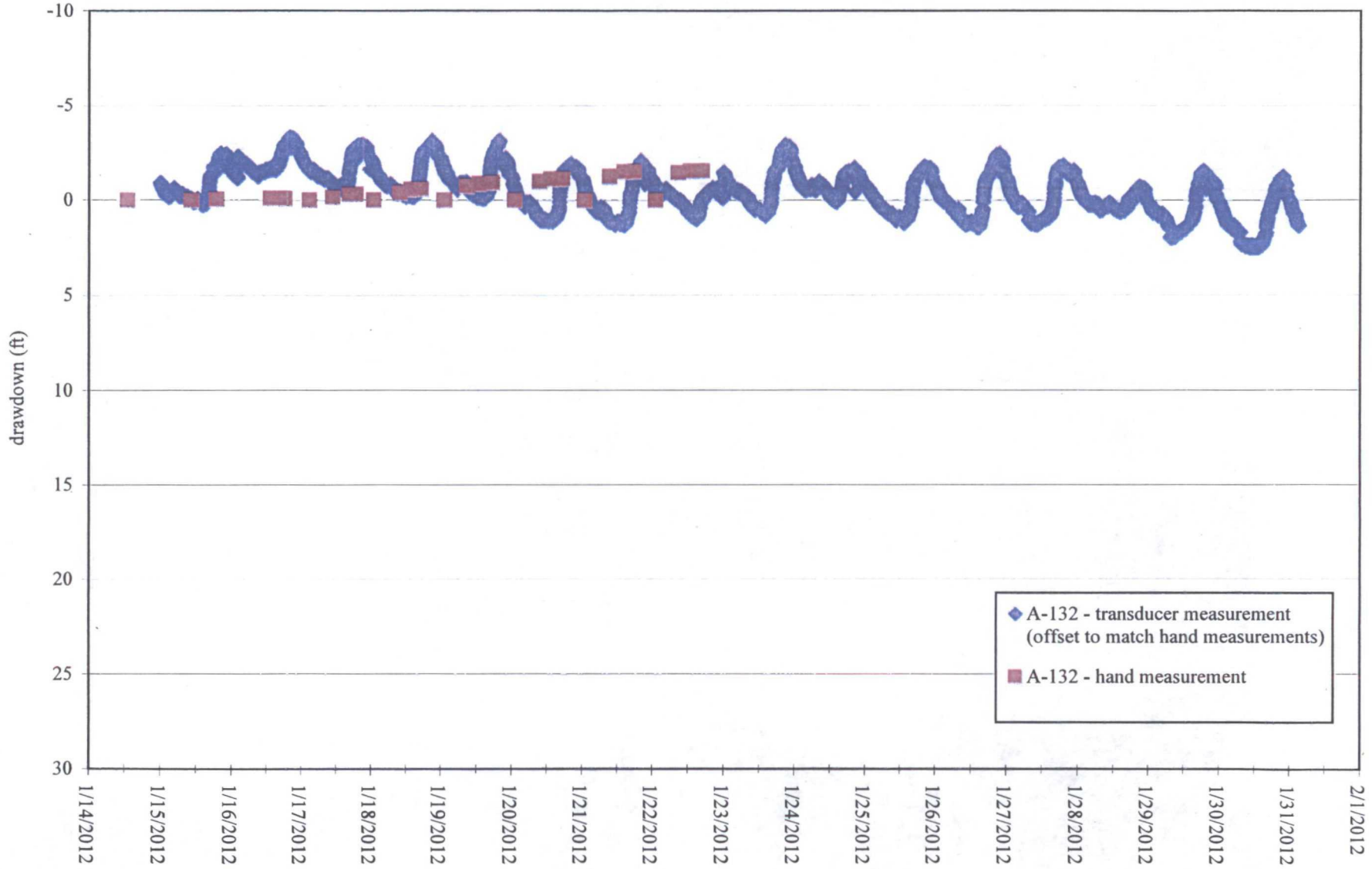

Figure 13. Drawdown in Well A-132 during closed-loop test.

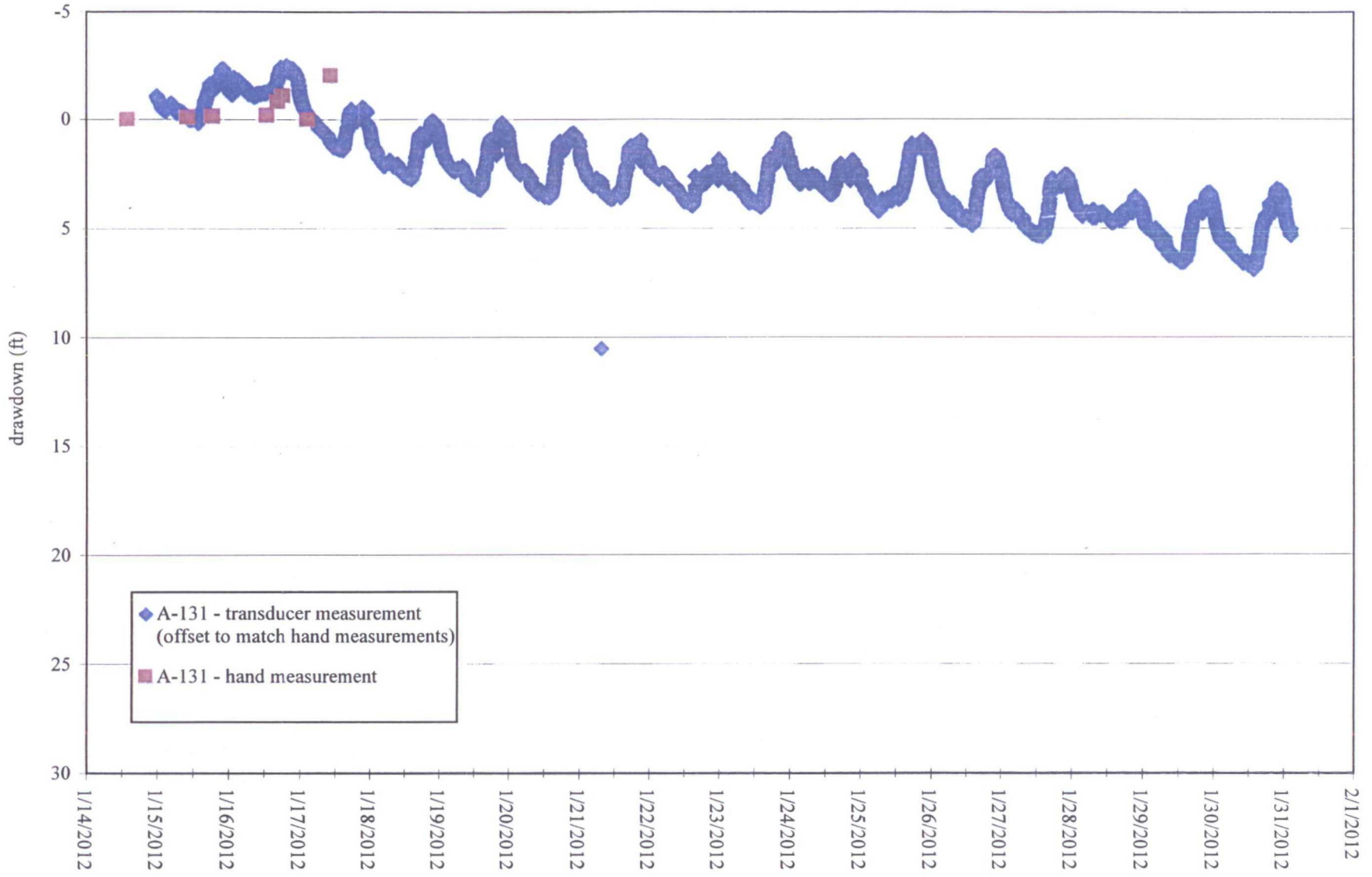

Figure 14. Drawdown in Well A-131 during closed-loop test.

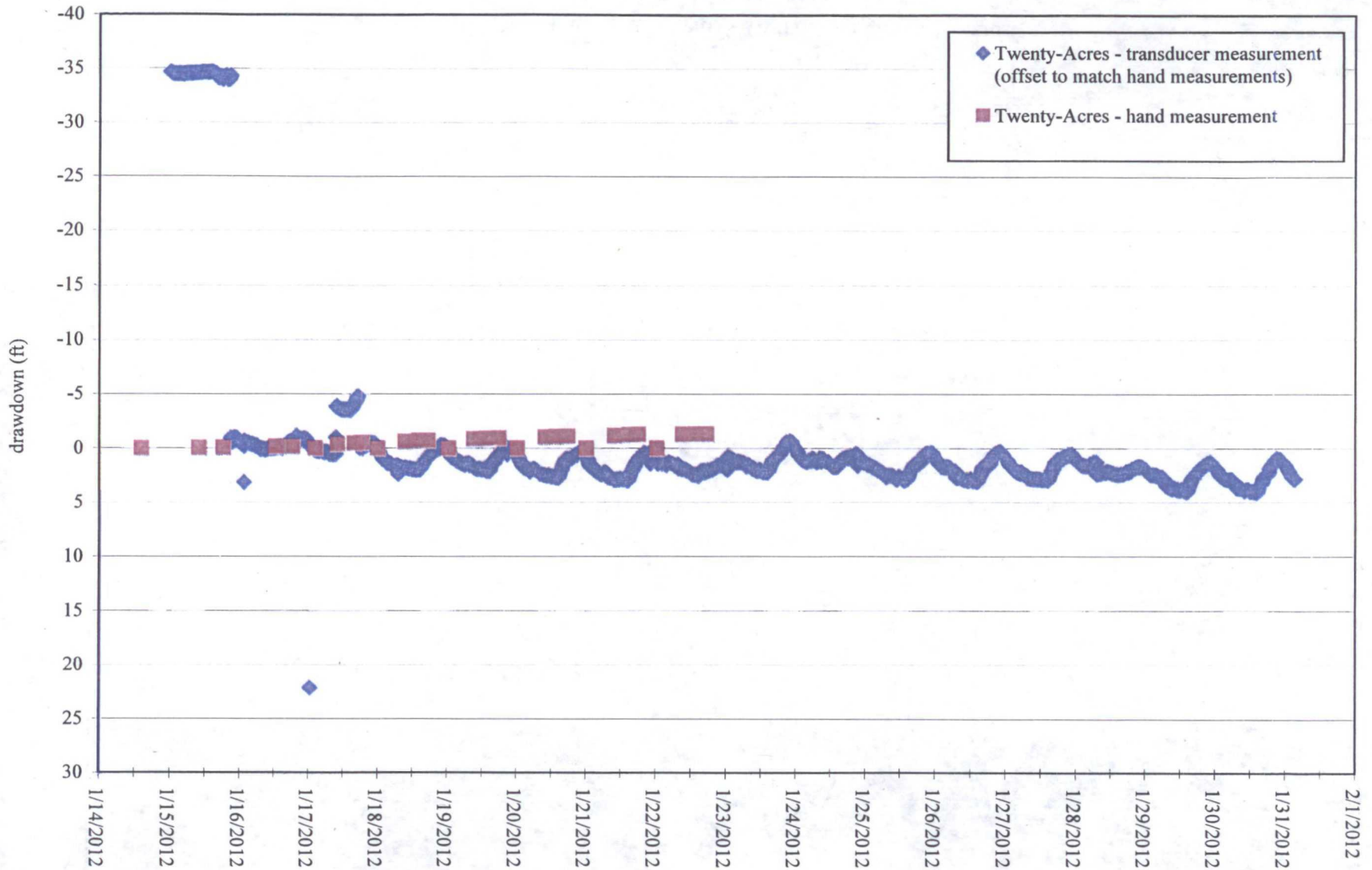

Figure 15. Drawdown in Twenty-Acres Well during closed-loop test.

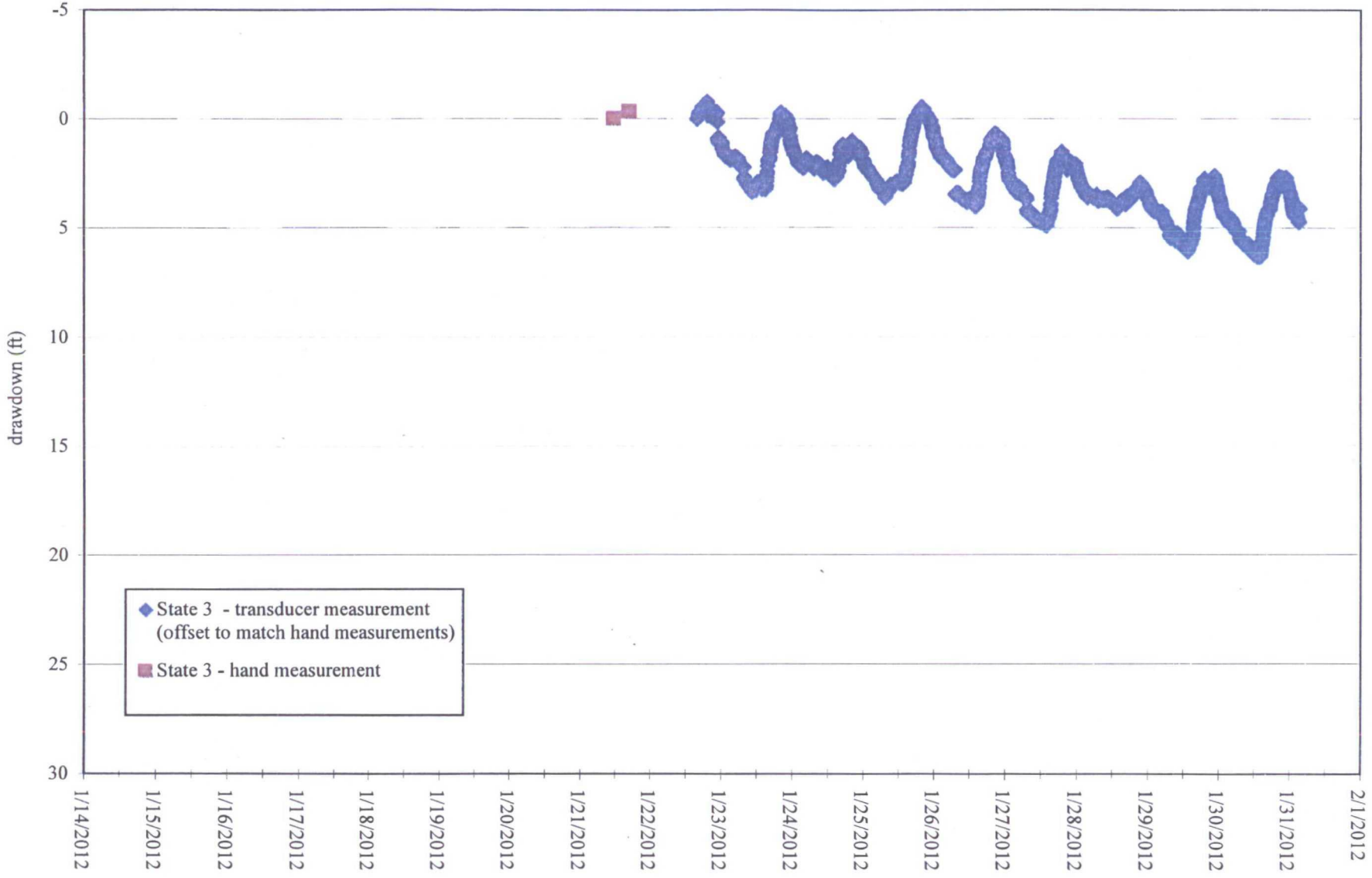

Figure 16. Drawdown in State No. 3 Well during closed-loop test.

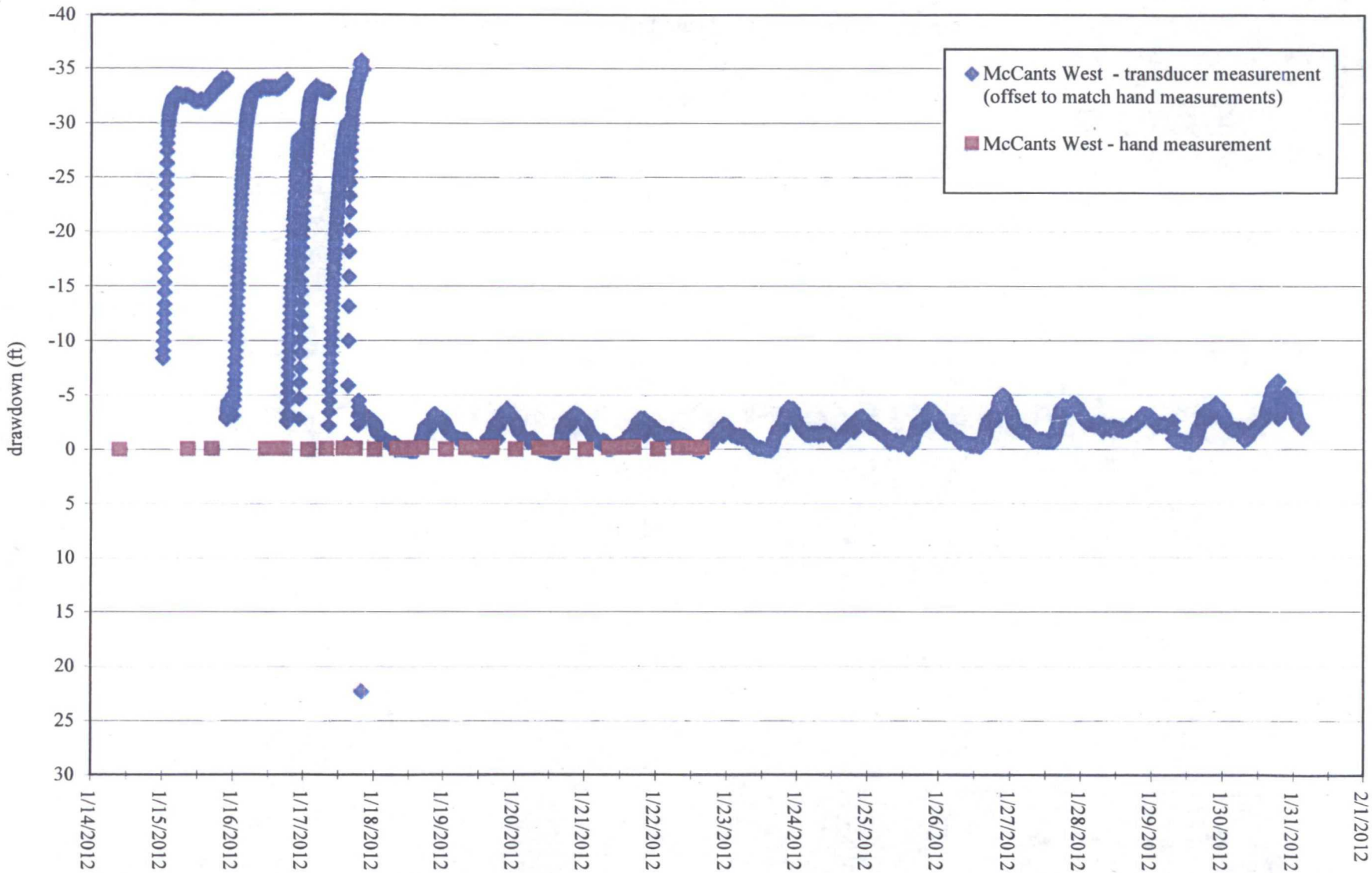

Figure 17. Drawdown in McCants West Well during closed-loop test.

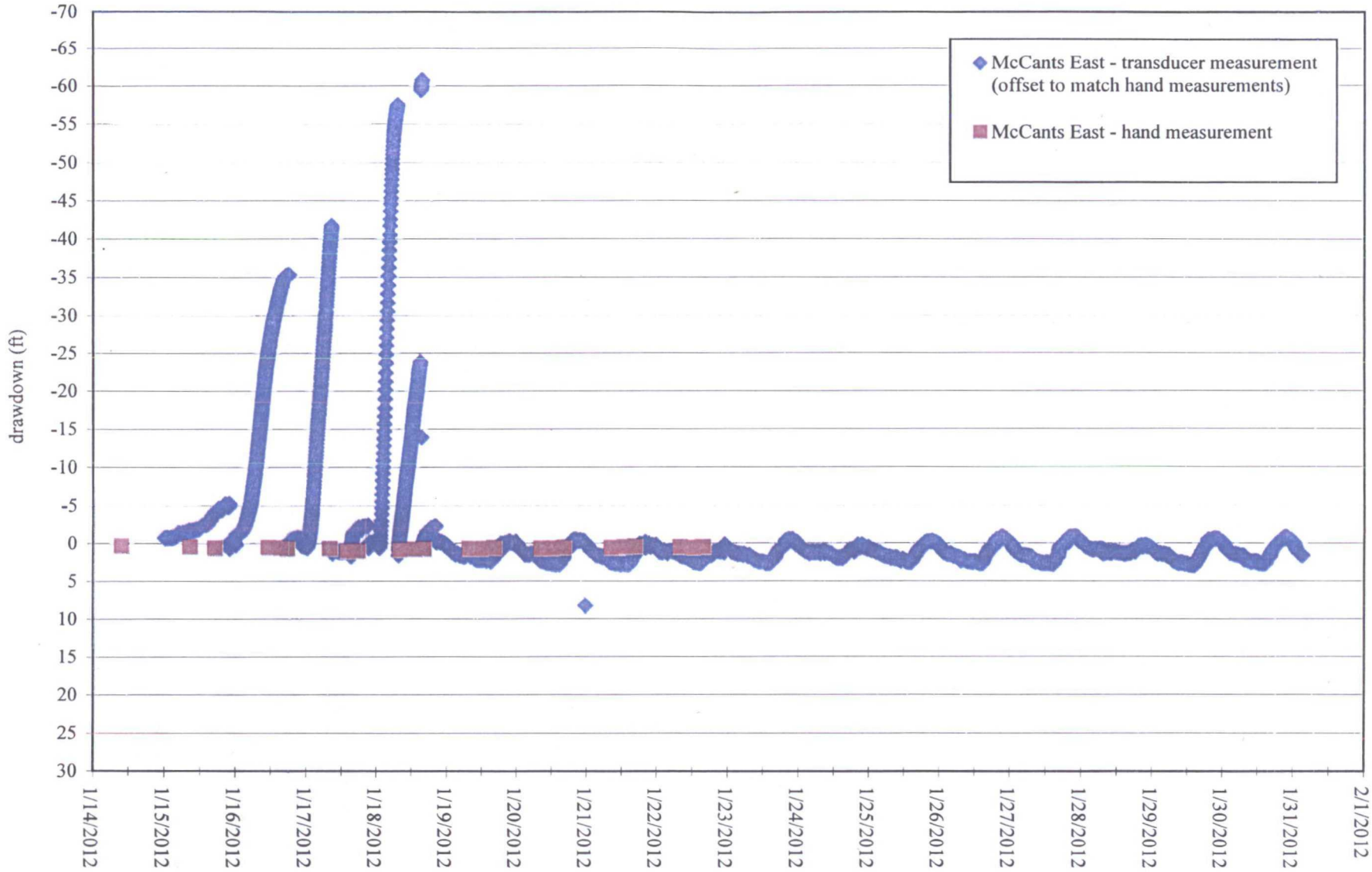

Figure 18. Drawdown in McCants East Well during closed-loop test.

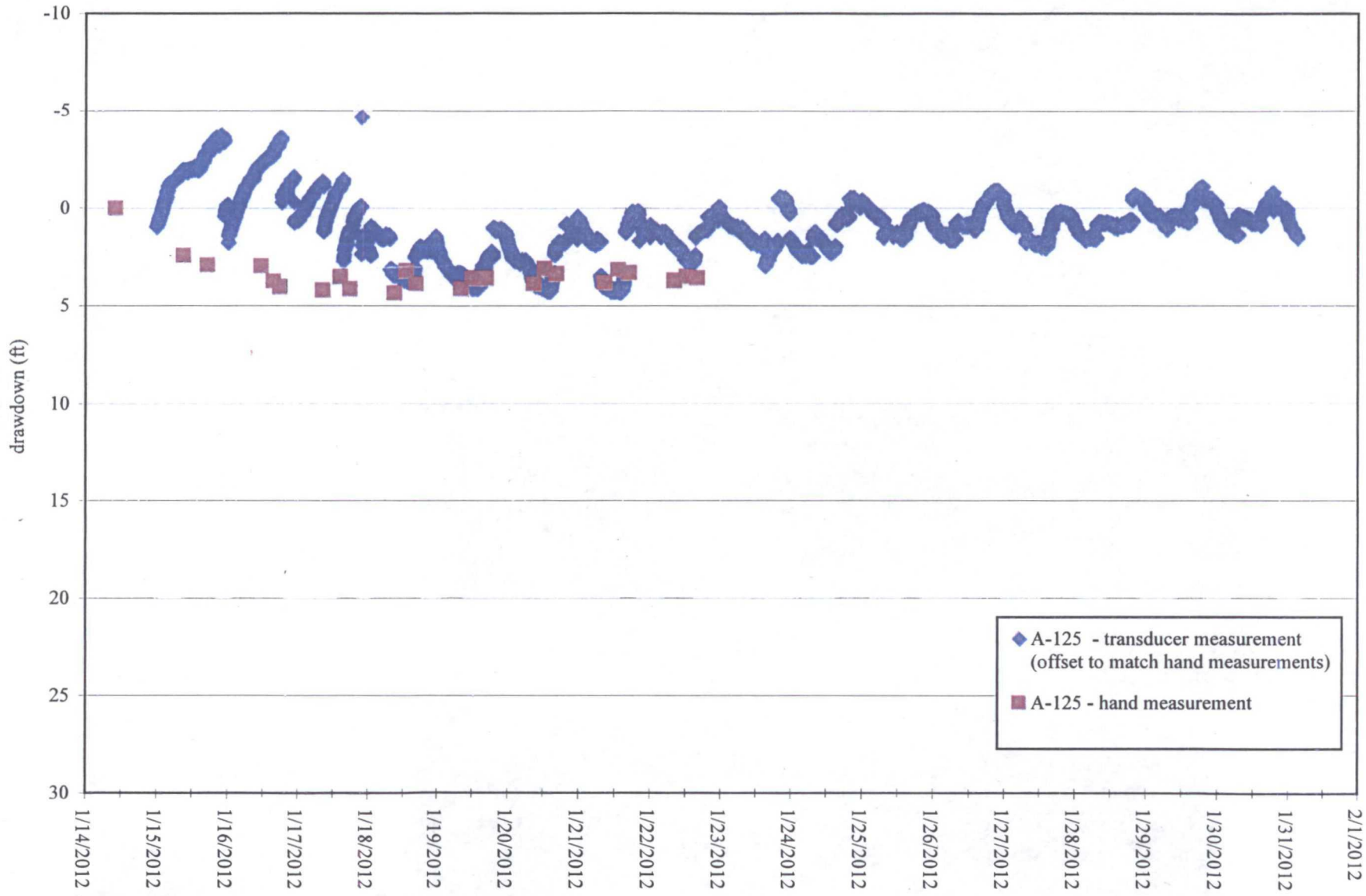

Figure 19. Drawdown in Well A-125 during closed-loop test.