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## TECHNICAL MEMORANDUM

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To: John Conley and Andrea Felix, Enduring Resources

From: John Shomaker

Date: October 30, 2018; revised November 1, 2018

Subject: Results of preliminary pumping test, SJ-4301 POD1, October 26-28, 2018

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### INTRODUCTION

This memorandum will summarize the results of the preliminary pumping test of Enduring's North Escavada Unit 2207-16B Water Supply Well, State Engineer Well No. SJ-4301 POD1, conducted on October 26-28, 2018 under an exploratory-well permit. Although further test pumping is contemplated, this test provided adequate data from which to determine aquifer characteristics. Daniel Apodaca of John Shomaker & Associates observed much of the testing. Spreadsheets showing the data collected by Enduring's contractors, and which underlie the conclusions in this memorandum, will be submitted with this memorandum but as separate files. Logs and completion information for the well have been, or will be, submitted separately to the State Engineer by Enduring.

### DESCRIPTION OF PUMPING TEST

#### Equipment and Procedure

The producing interval in the well is the Entrada Sandstone, between 6,892 and 7,107 ft below ground level (bgl). The well was completed with shot perforations in the cemented 7-in. casing between 6,925 and 7,114 ft, and stimulated by hydraulic fracturing. The pump is a 480 hp Summit SK15500 49-stage submersible, set at 6,332 ft bgl on 3-1/2-in. tubing. Water levels were measured by a pressure transducer integral with the pump, and also using an Echometer sonic water-level indicator from the surface. Because of the high salinity of the water (final specific conductance was measured at 23,210  $\mu\text{S}/\text{cm}$ ), the large variation in the temperature from beginning to end of the test (36°F to 161°F), and the long water column in the well, no attempt was made to adjust the pressure transducer readings for fluid density to obtain depths to water, but rather were normalized to be consistent with the direct Echometer readings. Transducer measurements were taken at 1-minute intervals. The pumping rate was measured, in barrels, by a totalizing meter and recorded each hour; the rates were converted to gallons per minute (gpm) for purposes of interpretation. The water was discharged to a lined pond, to be stored for later use as permitted by the State Engineer.

### Pumping Test Data

The pumping period was 1,811 min, with an average rate of 189.7 gpm as shown in Figure 1 and in the spreadsheet *Enduring SJ-4301 POD1 N Escavada Pond 1 hourly totalizer.xls*. Although the pumping was against a choke, there was no attempt to make fine adjustments in the rate. Even so, the variation was small, a total range of about 5 gpm or 2.6 percent of the average rate, and because the purpose of the test was to determine aquifer transmissivity from the recovery data as discussed below, the variation was considered acceptable.

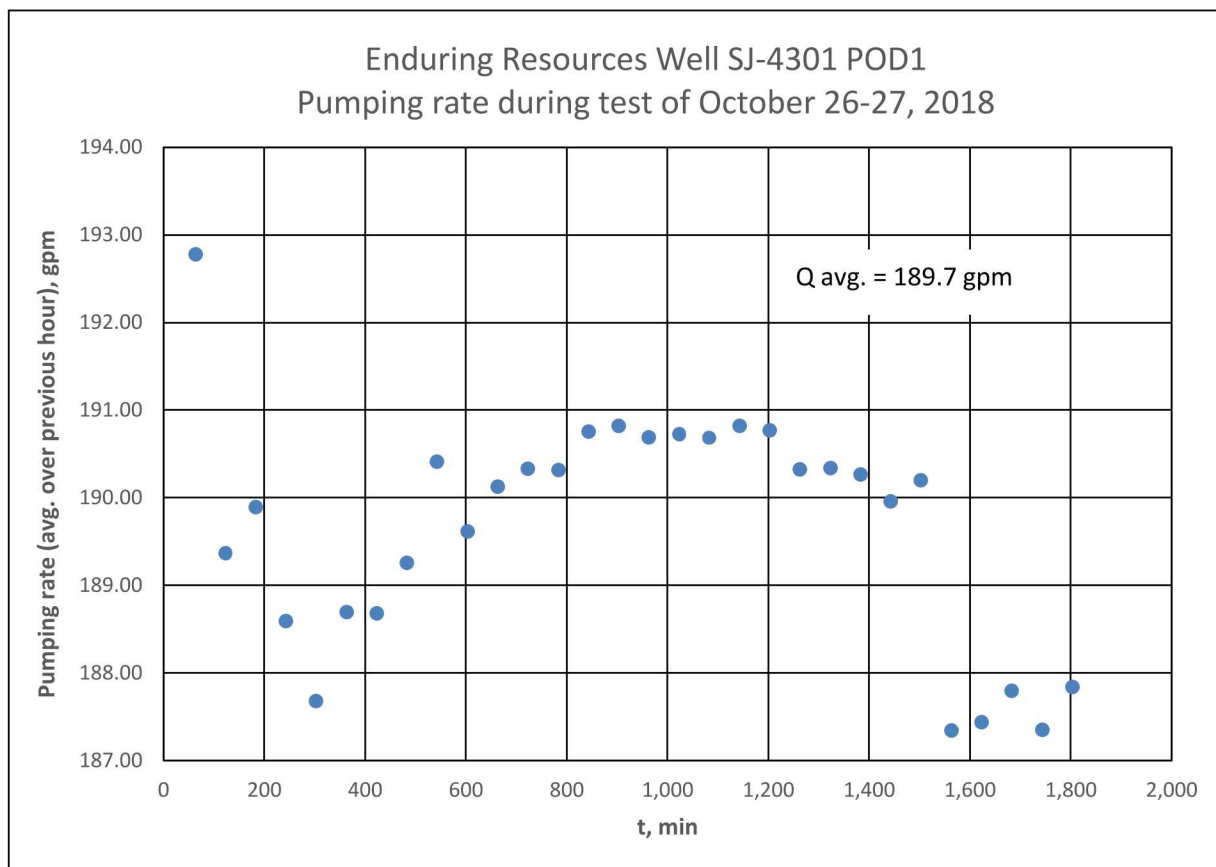


Figure 1. Pumping rates during the test of Enduring Resources Well SJ-4301 POD1, October 26-28, 2018.

Water levels during pumping are shown in Figure 2 and in the spreadsheet *Enduring SJ-4301-POD1\_test\_data.xls*. The water levels shown were those measured with the Echometer only, because of the density variations discussed above. The depth to water was roughly constant at about 740 ft bgl through 662 min of pumping, then the water level rose rapidly to reach about 718 ft at the end of the pumping period. This preliminary test was the first pumping since the frac stimulation, and the well made significant amounts of both frac sand and formation sand during pumping. It is clear from the water-level record that well-development continued throughout, and for that reason no attempt was made to interpret the drawdown data. As of the final measurement at 1,804 min, the specific capacity was about

0.62 gpm/ft (gallons per minute per foot of drawdown), but the value is expected to be higher after a similar period of pumping once well-development is complete.

The water was sampled frequently during pumping for temperature and specific conductance. A sensor at the pump recorded temperatures, which ranged from 157°F to 161°F for most of the period. As discharged at the surface, the final water temperature was 137°F. The final value for specific conductance was 23,210  $\mu\text{S}/\text{cm}$ . A set of water samples was collected and preserved, and has been submitted to Hall Environmental Laboratory for analysis. The analytical results will be provided as soon as they are received from Hall.

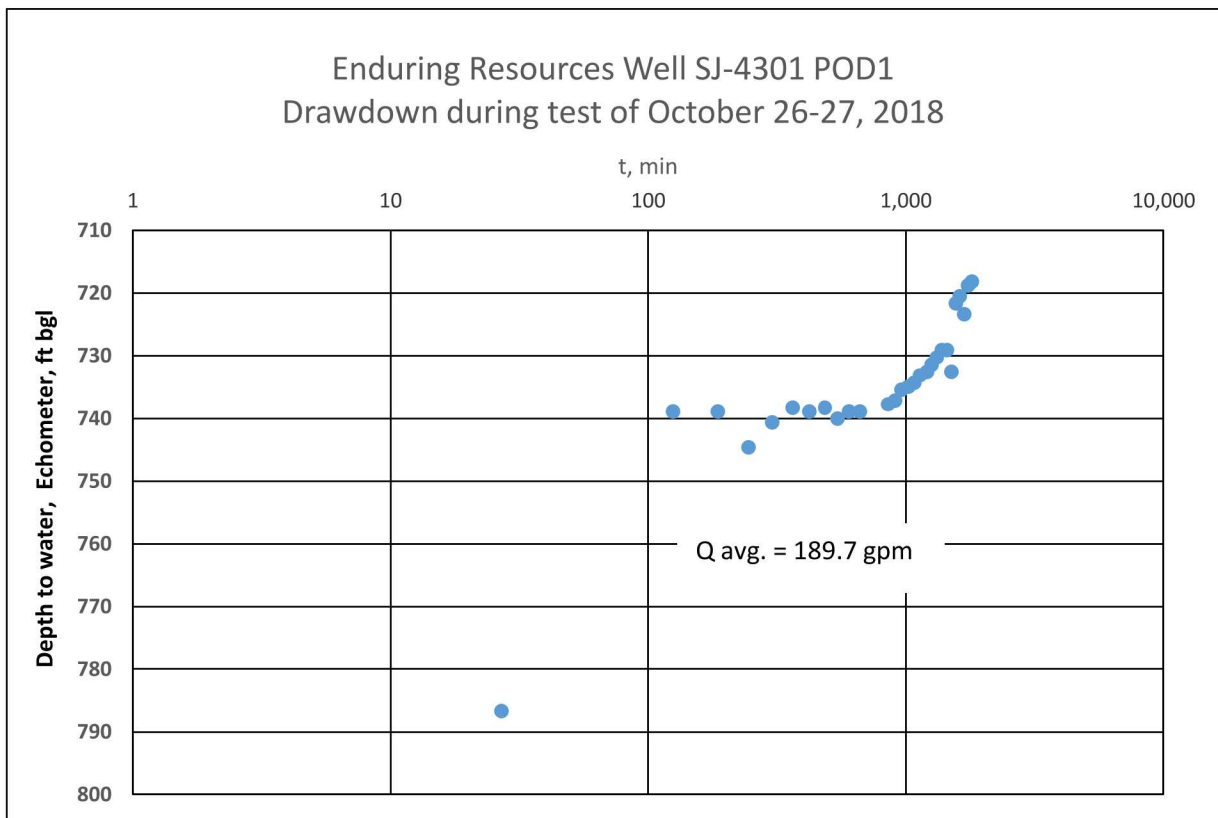


Figure 2. Depth to water during pumping during October 26 and 27, measured by Echometer, test of Enduring Resources Well SJ-4301 POD1, October 26-28, 2018.

Recovery measurements were taken for 1,439 min after pumping stopped. Figure 3 shows the recovery measurements plotted against the ratio  $t/t'$  (time since pumping began divided by time since pumping stopped), for analysis by the conventional Cooper-Jacob method<sup>1</sup> to determine confined-aquifer transmissivity. Transmissivity is the product of mean hydraulic conductivity times aquifer thickness, and is calculated based on the prevailing temperature and viscosity. Direct measurements of the groundwater head are used in the calculation, and for that reason values for the head above the pump intake, as measured by the

<sup>1</sup> Cooper, H.H., and Jacob, C.E., 1946, A generalized graphical method for evaluating formation constants and summarizing well field history: American Geophysical Union Transactions, v. 27, pp. 526-534.



pressure transducer integral with the pump, were normalized to conform with the Echometer measurements of actual depth to water. The data and calculations are shown in the spreadsheet *Enduring SJ-4301-POD1\_test\_data.xls*.

### Aquifer Characteristics

The recovery plot shows a small mounding effect attributable to draining of the 3-1/2-in. tubing after pumping stopped (there was no check valve in the tubing), ending about 10 minutes after pumping stopped. Thereafter, the plot follows the classic confined-aquifer straight line, with a slope of about 64 ft per log cycle. Transmissivity calculated from that slope and the average pumping rate of 189.7 gpm is 780 gpd/ft (gallons per day per foot) or 104 ft<sup>2</sup>/day. There is no change in slope that would indicate a recharge or barrier boundary condition.

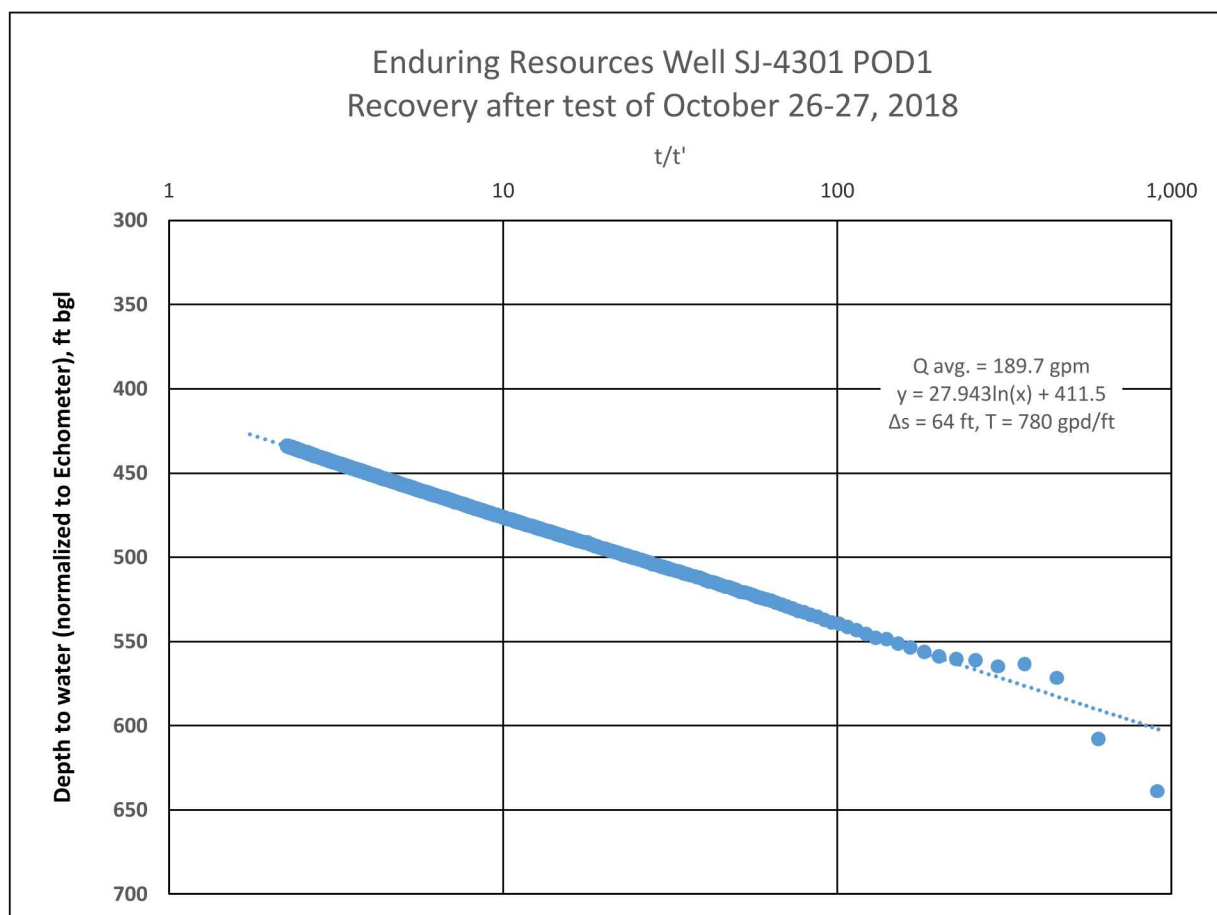


Figure 3. Depth to water during recovery after pumping, measured by pressure transducer with measurements normalized to conform with Echometer measurements, test of Enduring Resources Well SJ-4301 POD1, October 26-28, 2018.

Because the well had not been developed and allowed to fully recover before the test began, no long-term, non-pumping water level measurement was available. However, a value of 411.5 ft bgl (6,491 ft elevation) at infinite time ( $t/t' = 1$ ) can be projected from the recovery plot. A single-well test would not provide a reliable determination of storage coefficient, but

a value based on the conventional assumption of  $2 \times 10^{-6}$  per foot of thickness, or 0.00043, would be appropriate for effects calculations.

The aquifer characteristics of the Entrada Sandstone in Well SJ-4301 POD1 are similar to those calculated for the Cherokee & Pittsburg water wells completed in the Entrada Sandstone in the same part of the San Juan Basin, as shown in Table 1.

**Table 1. Summary of aquifer characteristics, Enduring Resources Well SJ-4301 POD1, and comparison with existing Cherokee & Pittsburg Entrada Sandstone water wells.**

	<b>Cherokee &amp; Pittsburg No. 2 Gallo Wash SJ-549-Expl. 1</b>	<b>Cherokee &amp; Pittsburg No. 3 Gallo Wash SJ-549-Expl. 2</b>	<b>Enduring Resources Well SJ-4301 POD1</b>
Location	SE/4 Sec. 16, T. 21 N., R. 9 W.	NW/4 Sec. 16, T. 21 N., R. 9 W.	NE/4 Sec. 16, T. 22 N., R. 7 W.
Year drilled	1978	1978	2018
Depth to top, Entrada Sandstone, ft bgl	5,532	5,500	6,892
Entrada Sandstone thickness, ft	162	211	215
Depth to water (projected), ft bgl	23.3	6	411.5
Water level elevation, ft	6,395	6,396	6,491
Pumping test rate, gpm	402	616	189.7
Specific capacity, gpm per ft drawdown	0.53	1.23	>0.62
Transmissivity, gpd/ft (ft <sup>2</sup> /day)	980 (131)	1,145 (153)	780 (104)
Water temperature (as discharged), °F	144	144	137
Total dissolved solids, mg/L	10,630	10,200	9,980 (see note)

Note: Enduring SJ-4301 POD1 sample is from final swab run, October 9, 2018. TDS of water produced during pumping test of October 26-28, 2018 is expected to be significantly higher based on specific conductance.

### EFFECTS OF PUMPING

The relatively small drawdown during pumping at 189.7 gpm, and the short-term specific capacity of the well, expected to be greater than 0.62 gpm/ft, indicate that the well will be capable of producing at the annual rate of 942 ac-ft/yr (20,000 BWPD or 584 gpm) that is contemplated in the Notice of Intention.

Applying the values for transmissivity of 780 gpd/ft and storage coefficient of 0.00043, as described above, in the Theis equation<sup>2</sup> leads to the predicted incremental drawdown effects within the Entrada Sandstone aquifer shown in Table 2. The theoretically available drawdown between the non-pumping water level of 411.5 ft and the top of the aquifer at 6,892 ft is 6,481 ft. At a short-term specific capacity of 0.62 gpm/ft, the drawdown at 584 gpm would be 942 ft. Adding that to the incremental effect at 40 years of 1,956 ft leads to a total drawdown of 2,898 ft. The actual drawdown is likely to be less because of the effect of upward leakage, over a very large area, from the underlying Chinle Formation.

<sup>2</sup> Theis, C.V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage: American Geophysical Union Transactions, v. 16, pp. 519-524.

**Table 2. Theis-equation predicted incremental drawdown effect of pumping 942 ac-ft/yr from Enduring Resources Well SJ-4301 POD1, based on the transmissivity and storage coefficient values described in text.**

Distance	Incremental drawdown, ft		
	1 year	10 years	40 years
at well (r = 1 ft)	1,639	1,837	1,956
1,000 ft	454	652	771
1 mile	175	367	485
5 miles	4	106	213
10 miles	0	27	106

Although there will be large drawdown effects in the Entrada itself, no actual net depletion is likely to result from the proposed pumping because the water will be used as drilling water and in well stimulation for oil and gas production, and, except for minor incidental losses, will be injected into petroleum-producing intervals shallower than the Entrada for well stimulation, or will be injected into salt-water disposal wells as produced water from the oil and gas wells. Almost all of the currently permitted San Juan Basin disposal wells are completed in the Entrada, and sometimes in additional, shallower zones.

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State of New Mexico  
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CONDITIONS

Action 300690

CONDITIONS

Operator: NEW MEXICO ENERGY MINERALS & NATURAL RESOURCE 1220 S St Francis Dr Santa Fe , NM 87504	OGRID: 264235
	Action Number: 300690
	Action Type: [IM-SD] Well File Support Doc (ENG) (IM-AWF)

CONDITIONS

Created By	Condition	Condition Date
pgoetze	None	1/7/2024