

# APPENDIX A

## Drill STEM TEST RESULTS DEEP BASIN AQUIFER ROCKS

The DST charts received from operators in the Palo Duro Basin have been analyzed according to the Horner method (Horner, 1951). The equation described by Horner (Eq. A1) is an approximation of an exact solution for pressure changes in a single well in an infinite reservoir:

$$P_w = P_o - \frac{q\mu}{4\pi kh} \ln \left( \frac{t_o + Dt}{Dt} \right) \quad (A1)$$

$h$  = thickness of the tested interval in feet (ft)

$k$  = average permeability in millidarcies (md)

$P_o$  = undisturbed formation pressure (psi)

$P_w$  = pressure at the well bore (psi)

$q$  = rate of production

$q_a$  = average rate of production in the previous flowing period (bbl/day)

$t_o$  = length of production time (h)

$Dt$  = elapsed time since pressure build-up began after final production period (h)

$\mu$  = viscosity of the fluid (cp)

On conversion of equation A1 to standard units employed by the petroleum industry, the expression becomes:

$$P_w = P_o - \frac{162.6 q_a \mu}{kh} \log \frac{t_o + Dt}{Dt} \quad (A2)$$

A semi-log plot of the pressure data against  $\log (t_o + Dt/Dt)$  should approach a straight line after the early production effects have diminished. The slope (m) of the straight-line portion of this plot is computed as:

$$M = \frac{\Delta P_w}{\text{cycle of } \log (t_o + Dt/Dt)} \quad (A3)$$

which reduces equation A2 to:

$$K = \frac{162.6 q_{\mu}}{Mh} \quad (A4)$$

Extrapolation of the straight line according to equation A5:

$$\log \frac{t_o + Dt}{Dt} = 0 \quad (A5)$$

will yield the estimated undisturbed formation pressure where  $P_w = P_o$ .

The data listed in Table A-1 summarize the results of Horner analyses for DST's in the deep basin aquifer system. The subscripted values,  $K_1$  and  $H_1$ , are for the initial shut in pressure (ISIP), and  $K_2$  and  $H_2$  refer to values from the final shut in pressure. Equivalent fresh water heads,  $H_1$  and  $H_2$ , were computed from each extrapolated estimate of formation pressure by dividing by 0.433 psi/foot and correcting for elevation.



# WOLFCAMP DST RESULTS

County	Well # API	BEG#	Company Lease	Tested Interval Depth (ft. below l.s.)	Interval thickness (ft)	PI Formation Code	Equivalent F.W. Head H <sub>1</sub> H <sub>2</sub>	Recovery	Permeability average k <sub>1</sub> k <sub>2</sub>	Effective k <sub>1</sub> k <sub>2</sub>	Method of analysis	Lithology	Comments
Briscoe	42 04530001	21	Cockrell Attard #1	6544-6411	67		3105 2964	4390	8.5 1.31		Horner	mid to lower shelf	
Carson	42 04530182	38	Shenandoah #1 Kohara	3601-3615	14		1533 1501	60	1.7 0.3		Horner	back shelf	
Castro	42 06960003	1	Amerillo Yeager #1	6909-7059	150		2500 2505	4692	64 26		Horner	porous dolomite	
Castro	42 06960014	7	Union Oil Formwalt #1	5183-5228	45		2750	3050	7.6		Horner	slightly porous dolomite	
Castro	42 06960014	7	Union Formwalt #1	5838-5932	94		2206 2206	1116					
Castro	42 06930002	10	Phillips Morris #1	6762-6782	20		2560 2483	200	0.66 0.27		Horner	slightly porous dolomitic limestone	
Childress	42 07560005	76	WES TEX Mitchell #1	2633-2663	30		1818 1781	60	0.95 0.03		Horner	dolomite limestone	
Cottle	42 10110217	10	Murphy Timmons #1	3169-3178	9		1867 1897	670	15.5 8.8		Horner	slightly calc. dolomite	
Donley	42 12960001	31	Shell Finch #1	3350-3399	49		1797 1754	404	0.51 0.79		Horner	porous limestone (upper W.F.C.)	
Donley	42 129		DOE Sawyer #1	2950-3123	173		1413 1366	257	0.09 0.09		Horner	slightly porous anhydritic limestone	
Floyd	42 15330194		Amoco Sally Reeves #1	5500-5581	81		2081 2081	930	8.9 8.3		Horner		
Floyd	42 15330008		Ken Fol. Co. Howard #1	4660-4750	90		3597 2392	1146	0.68 0.59		Horner		
Hale	42 18910202	6	Mobil Laney #1	7864-8036	172		2583 2461	2070	1.04 0.10		Horner	slightly porous l.s. Top Penn	

# Wolfcamp DST Results

County	Well #	Ref #	Company Lease	Tested Interval		PI Formation Code	Eq. min. F.W. Head		Recovery	Permeability (md)		Method of analysis	Lithology	Comments
				Depth (feet)	Thickness (feet)		H <sub>1</sub>	H <sub>2</sub>		average k <sub>1</sub> k <sub>2</sub>	effective k <sub>1</sub> k <sub>2</sub>			
Hall	42 191 30001		Americas Lewis #1	3365-3390	25		1890	1830	185	0.62	0.44	Horner		
Hartley	42 205 35008	13	Standard Johnson #1	3520-3623	103			1381	600	0.77		Horner	Anhydritic dolomite	
Hartley	42 205 35008	13	Standard Johnson #1	3824-3890	66			1796	720	1.0		Horner	limestone	
Hartley	42 205 35008	13	Standard Johnson #1	4896-4940	44			1574	60	0.24		Horner	calcareous sandstone	
Hartley	42 205 00023	16	Standard La Ham #5-1	3916-3957	41			3007	720	1.75		Horner	Dolomitic limestone	
Lamb	42 279 30045		Gulf Energy/Min Blackwell #1	7352-7404	52		2515	2510	5550					
Motley	42 345 00015	13	Grande Prairie #1	4674-4715	41		1950	1947	2261					
Oldham	42 359 00026	4	Shell Fulton #6-1	3446-3471	25		1945	1908	1200	27	44	Horner	upper wolfcamp	
Oldham	42 359 30001	48	Shell Alamosa #1	5340-5367	27		1824	1741	974	1.0	0.6	Horner	limestone	
Oldham	42 359 00030		Shell Fulton #1-51	3416-3571	155		2346	2153	130	0.21	0.006	Horner	dolomite	
Potter	42 375 35013	26	Rice Williams #1	3907-4050	143		1486		1599	262		flow period analysis curve match	poreous dolostone	
Randall	42 381 60028		Ray Furr Brinkman A-1	5340-5361	21		2028		3200					
Swisher	42 457 60012	8	Burdell Rodford #1	5765-5796	31		2360		420	0.1		Horner		



### Wolfcamp DST Results

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# PENNSYLVANIAN DST RESULTS

County	WELL #	Company LEASE	TESTED INTERVAL		PI formation code	Equivalent FW. HEAD		Recovery	Permeability		(md) effective		Method of k analysis	lithology	Comments
	API REG#		DEPTH (ft below I.S.)	Thickness (feet)		H <sub>1</sub>	H <sub>2</sub>		Average k <sub>1</sub> k <sub>2</sub>	k <sub>1</sub> k <sub>2</sub>					
409 UNDIFFERENTIATED															
Hall	42 191 30101	Ensley Expt. Inc. Perry #1	4814-4832	18	409 FSLV	1673	1410	391	2.16	2.21			HORNER	reef	
Lamb	42 219 30007 116	Gulf DRH #1	8070-8100	30	409 PSLV	2591	2586	6680	31.2				flow period curve match		
Lamb	42 279 30057 116	Gulf DRH #1	8385-8522	137	400 PSLV	2593	2613	5526		19.2			Horner		
Potter	42 375 35013 26	ENRICE WILLIAMS #1	5652-5710	58	409 PSLV	1752	1752	1900	18.9	10.1			Horner	arkosic l.s. coastal No l.s.	
406 VRGL															
Oldham	42 359 00025	Shell Almona Ranch #1	6095-6130	35	406 VRGL	2122		4500	44.5				Horner		4000 ft oil recov gas to surface 1 gas 76 MCFD 11 gas k = 0.0
Oldham	42 359 00025	Shell L.S. Ranch #1	6907-6931	24	406 VRGL	2314		630	1.4				Horner		
405															
Castro	42 069 60003 1	Amerrillo oil Co VIEGEL	7782-7828	46	405 CNRF? 404 STN #2	3065	2324	300	56	.1			Horner	slightly porous chalky limestone	
Cottle	42 101 20094	Gus Edwards #2	4342-4350	8	405 CNRF	1705	1685	3650	80.9	462			flow period curve match	reef	
Cottle	42 101 20020 96	Gus Edwards #1	4412-4421	9	405 CNRF		1719	4085	323.9				flow period curve match	canyon reef limestone	
Cottle	42 101 00026 113	Gulf Shamberg #1	4980-5051	71	405 CNRF		1798	4700	694				flow period curve match	limestone	



# PENN DST RESULTS

County	WELL# API	COMPANY LEASE	TESTED DEPTH# (ft below l.s.)	INTERVAL THICKNESS (feet)	PI Formation CODE	Equivalent FW Head		Recovery	Permeability (md)				method of k analysis	lithology	Comments
	BEG#					H <sub>1</sub>	H <sub>2</sub>		average K <sub>1</sub>	K <sub>2</sub>	effective K <sub>1</sub>	K <sub>2</sub>			
405															
Hartley	42 205 30013	Big Chief Drilling Co Capitol #1	7190-7218	28	405 CNYN	1837	1253	840		.2			Horner		700 feet of recovery is gas
Oldham	42 359 00028	Shell (? 18) LS Ranch #1	8254-8278	24	405 MSSR		2255	270		2.6			Horner		gas to surface 10m gas K=D. 280 mcf/D @
Oldham	42 359 00015	Shell Fullon Ranch #1-A-80	6792-6839	47	405 MSSR	2251	2029	3060	19.8	16.1			Horner	limestone	
Oldham	42 359 00024	Shell (? 40) Strat #58	6648-6698	50	405 MSSR	2230		4200	51.1				flow period curve match		
Swisher	42 437 60015	Chambers and Kennedy Fidgers #1	8260-8315	55	405 CNYN	2261	2092	1704	5.4	4.4			Horner		
404															
Cottle	42 101 00026	Gulf Shamberger #1	5523-5573	50	404 STRN	1464		2220	15.6				Horner	limestone	
Cottle	42 101 00068	Shell Willford #1	6768-6846	78	404 DMSD	1816	1762	1530	5.4	2.0			Horner	sand	
Cottle	42 101 00068	Shell Willford #1	6044-6075	31	404 DMSD	1205	1233	500	.6	.2			Horner	sand	
Motley	42 345 00017	Gen Crude Firing	8563-8577	14	404 GRSD	3172		638	.32				Horner	sand	
Floyd	42 153 30003	Cockrell Kerstetter #1	8350-8524	174	404 STRN	4091	3865	2435	1.5	0.2			Horner		

PENN DST RESULTS

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# Granite Wash DST results

County	Well # API	Company BEG #	Lease	Tested Interval Depth (feet) to below L.S.	Interval Thickness (feet)	PI Formation Code	Equivalent F.W. head H <sub>1</sub> H <sub>2</sub>			Recovery	Permeability average K <sub>1</sub> K <sub>2</sub>	viscosity (md) effective K <sub>1</sub> K <sub>2</sub>	method of Kandysis	lithology	Comments
000 GRWS															
Donley	42 129 60001	31	Shell Finch #1	4686-4790	104	000 GRWS	1555 1501			1714	1.6 1.5		Horner	80' granite wash	
Hall	42 191 60001	1	Amarillo oil Co Cochran #1	4637-4654	17	000 GRWS	1591 1529			150	0.7		Horner	5' 1st 5' granite wash 7' shale	1st flow 0.75 min K = 0.7 based on total flow period
Hartley	42 205 35025	36	Standard Oil Co Alice Walker 1-26	6290-6314	24	000 GRWS	1312			1920	282		Horner		
Hartley	42 205		Standard Oil Walker 1-45-5	6108-6140	32		3084			240	0.09		Horner		
Motley	42 315 00018	9	Gen Crude Fish #1	8736-8752	16	000 GRWS	2654			300	0.09		Horner		
Oldham	42 359 00015		Shell Fulton #A-1-84	6282-6320	38		2330			4380	138+		flow period curve match		
Oldham	42 359 30001	48	Shell Alamosa 1-315	7047-7069	22	000 GRWS	2331 2267			3397	17.7 11.9		Horner	dolomitic l.s. and granite wash	
Oldham	42 359 30001	48	Shell Alamosa 1-315	7070-7100	30	000 GRWS	1527 487			2220	5.6 3.1		Horner	granite wash	
Oldham	42 359 30005	63	Royal Res. Tom Greene #1	7272-7312	40	000 GRWS	2354 2313			200	0.06 0.03		Horner	30' arkose l.s. K granite wash	
Oldham	42 359 00020		Shell Fulton Ranch 1-51	6198-6220	22		2283 2286			150	0.7 0.1		Horner	granite wash	
Oldham			DOE Mantled #1	7000-7409	409		2453 2453			3934					

## MISSISSIPPIAN DST RESULTS

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## Ellenburger DST Results

County	Well # API BEG #	Company Lease	Tested Interval		F.W. Head		Recovery (feet)	Permeability (md)		Method of Analysis	Lithology	Comments
			Depths (below land wt)	Thickness (feet)	H <sub>1</sub> (ft above a.l.)	H <sub>2</sub> (ft above a.l.)		Average K <sub>1</sub> K <sub>2</sub>	Effective K <sub>1</sub> K <sub>2</sub>			
Cottle	42 101 10207 17	Great Western Perfected #1	7739-8011	82	2050	2154	1723	1.27	1.6	Horner	slightly porous cherty dolomite	
Cottle	42 101 00068 36	Shell Williford #1	7391-7421	30	2098	2756	25	0.02	0.001	Horner	limestone	
Cottle	42 101 00026 113	Gulf Shamberg #1	7002-7051	49	1826		420	25.7		Horner	limestone	
Donley	42 129 60001 31	Shell Finch #1	6165-6228	63	1643	1643	4927	127.0		flow period curve match	cherty porous dolomite	
Gray	42 179 00010 1	E.B. Clark Burrnett #1	7575-7620	45	1629	1186	540	3.4	3.1	Horner		Est F.W. Head 1407 H <sub>1</sub> too high (flow 2 min) H <sub>2</sub> too low (67 flow 30)