DST Analysis, Super-Pickett Analysis to determine pay cut offs, integration of capillary pressure data with petrophysical log data, and material balance calculations to validate reservoir pressure history and drive mechanism – Schaben Field, Ness County, Kansas.

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The Schaben field is located in Ness County, Kansas. A detailed reservoir characterization and simulation study was carried out in the northern part of the field under a project funded by DOE's Class 2 program (under contract DE-FC22-93BC14987). The Schaben demonstration site consists of 1720 contiguous acres within the Schaben field and spreads over Sections 19, 29, 30, 31 and 32 in Range 21W/Township 19S and over Sections 23, 24, 25, 26, 35 and 36 in Range 22W/Township 19S (Figure 1). The objective of this study was to improve reservoir performance of mature oil fields, located in shallow shelf carbonate reservoirs of the Midcontinent, by demonstrating the application of cost-effective tools and techniques to characterize and simulate the reservoir.

Geologic data, production data, and petrophysical log data and their analyses are available over the Internet at http://www.kgs.ukans.edu/Class2/index.html and http://www.kgs.ukans.edu/DPA/Schaben/schabenMain.html.

DST and Pressure Analysis

Table 1 summarizes the analyses of DST data available for the Schaben field. The detailed DST analysis for each well is present in Appendix A. DST data was available only for a minority of the wells in the study area. Available shut-in pressures (initial shut-in pressure - ISIP and the final shut-in pressure – FSIP) were plotted (Figure 2) to obtain an understanding of the decline in reservoir pressure. The reservoir pressure declined from a maximum of 1410 psi (December 1963) to a minimum of1044 psi (May 1998). Since inception the field has produced without any pressure support and the limited reduction in the reservoir pressure indicates of a strong natural pressure support such as a bottom water drive.

Super-Pickett Analysis

The major part of the field was developed between 1963 and 1973. The available petrophysical log data is of different vintages especially the porosity log. The most commonly available source to determine porosity was from the micro-latero log (MLL). Density-neutron logs and sonic logs were available for some of the remaining wells. Super-Pickett cross-plots were used to analyze petrophysical logs. Table 2 summarizes the results of log analysis, and Appendix B contains the Super-Pickett plots from wells in the study area. Consistent Super-Pickett cut-offs were obtained with mud-filtrate resistivity (R_{mf}) values ranging between 0.055 to 0.099 ohm-m and the oil saturation in the flushed zone (R_{os}) ranging between 20 to 40%. S_w values derived from whole core analyses when compared with that calculated from well logs (MLL and deep resistivity) for wells Moore D1 (Figure 3) and Humburg 2A (Figure 4) showed acceptable matches and thereby confirming the validity of the values used for R_{mf} and R_{os}. Tabulation of the petrophysical properties of the perforated intervals revealed the cut-off parameters in Schaben field. For water free production, the BVW cut-off was found to be 0.103 while those for porosity and gamma ray were found to be 0.13 and 40 GAPI units. Wells were found to produce water-free when the BVW values in the perforated intervals was less than the cut-off though the S_w was averaged to be over 65%. The high BVW cut-off appears to indicate that micro-porosity present in the reservoir must be holding a significant volume of water immobile.

Mapping capillary pressure data on Super-Pickett plot

Whole cores from the Mississippian interval were available for the well Lyle Schaben No. 2P, and capillary pressure data were recorded on plugs obtained from this core (Figure 5). Figure 6 shows capillary pressure data mapped as contours (in feet, shown by magenta lines) of equivalent hydrocarbon column height (above free water level – FWL) on the Super Pickett plot. Expressing capillary pressure as height above the FWL is useful in comparing the column height with the stratigraphic depths of zones that have been color-coded on the Super-Pickett plot. Geologic mapping coupled with the analysis of recovery results from DST and production tests indicates that a uniform oil-water contact (OWC) exists across the study area at a depth of –2145 feet (subsea). The elevation of the kelly bushing for this well is at 2279 feet. The average depth of the perforated interval (4399 to 4404 feet, colored as red points) is 4401.5 feet, and it is therefore 22.5 feet above the OWC. In Figure 6, the perforated zone lies between the 21 and 24 feet contours. The capillary pressure data mapped on the Super-Pickett plot come from core plug samples numbered as 10, 15 and 42. The curved path followed by each pressure or hydrocarbon-column-height contour is a reflection of the overall change in pore-throat distribution with porosity within the petrofacies represented by the core plugs. A uniform trend of the pressure/height contours reveals that irrespective of porosity, within the range of porosity of the core plugs, the petrofacies has common value for microporosity. If plotted data came from plugs that belong to different petrofacies, then it would result in abrupt changes and disruptions in the trends of the capillary pressure/height contours. For petrophysically homogeneous reservoirs, a set of capillary pressure curves serves as reference features of a continuum, i.e., curves for intermediate porosities can be deduced by interpolating between the available curves. The breaks or disruptions in the contour trends indicate that interpolations are invalid because the plug samples, whose data have been plotted, belong to different petrofacies. Based on the Super-Pickett analysis, the BVW_i for the reservoir rock was assumed to be 0.103. The overlay of the capillary pressure data on the Super-Pickett plot (Figure 6) shows that for the average porosity of the pay interval, the state of irreducible saturation occurs at a minimum height of 24 feet above the OWC. Thus, the perforated interval in Lyle Schaben No. 2P can be expected to produce both water and oil, and upon testing it produced 53 bopd and 97 bwpd.

Material Balance Calculations – Schaben Field

The volumetric estimate of OOIP for the Schaben field (a Mississippian reservoir located in Ness county, Kansas) was calculated to be 37.8 MMSTB. This reservoir has been in production since 1963. The initial reservoir pressure was approximated at 1370 psi by using the DST pressure recordings from the early wells. PVT properties were generated by using standard correlations and the bubble point pressure was calculated to be 225 psi. All the wells in the field produce under artificial lift. The current fluid columns in most wells indicate that the reservoir is producing significantly above the bubble point pressure. Gas production at the surface has been negligible enough to escape any recording. Due to the lack of recorded gas production, it was assumed that the reservoir has no gas cap and the oil has no significant amount of dissolved gas in it. The main source of energy driving the production from the reservoir comes from the strong natural water drive.

For a reservoir with no gas cap and being driven by an aquifer, the generalized material balance equation gets simplified as:

$$\frac{F}{E} = N + \frac{W_e}{E}$$

where

$$E = E_o + E_{fw}$$

In the above equation, F denotes the underground withdrawal of fluids from the reservoir, E_o represents the change in volume of the oil and the dissolved gas, E_{fw} stands for the connate water expansion and the reduction in pore volume, and W_e stands for the reservoir volume of water that influxed from the aquifer. Also, the initial volume of oil in the reservoir is defined as N. This simplified material balance equation appears as a straight line, with an unit slope, when F/E is plotted against W_e/E and the Y-axis intercept (i.e. N) of this line estimates the OOIP. This estimate of the OOIP should be comparable to that obtained from volumetric calculations if correct assumptions have been made about the drive mechanism and in the calculation of the aquifer water influx. The material balance OOIP is considered to be the "active"[1] or "effective" initial oil in place in the reservoir, i.e., it represents the oil volume that contributes to the production and pressure history of the field. The volumetric OOIP is generally higher than that calculated by material balance because it includes immobile oil trapped in the reservoir heterogeneity. A difference, between the OOIP calculated from material balance and that calculated from volumetrics, of less than 10%[1] is regarded as an acceptable tolerance in the industry. Reservoir dimensions along with its petrophysical properties and cut-offs may need to be re-evaluated when the material balance OOIP exceeds that from volumetrics and there is confidence on the assumptions made in the mass balance calculations.

Water influx calculations are based on the geological and petrophysical assumptions about the aquifer. Incorrect choices of aquifer parameters will result in deviation of the data from the straight line when F/E is plotted against W_e/E. Modifications of the aquifer parameters through the process of “aquifer fitting” enables matching the observed pressure and production data to the geomodel describing the reservoir and the aquifer. Aquifer fitting assumes importance because most often very little is known about the aquifer geometry and petrophysics because wells are not planned to be drilled into the aquifer. Water influx from very small aquifers can be calculated by time-independent material balance equations. However, for large reservoirs the aquifer boundary takes a finite time to respond to reservoir pressure changes and thus time dependent models such as Hurst and van Everdingen, Fetkovitch, Carter and Tracy or Allerd and Chen are used to calculate the water influx, W_e.

An aquifer model that matches the reservoir pressure and production data is generally determined through a process of trial and error. However most often, satisfactory aquifer models are not unique. Problems regarding the data not falling along the expected straight line may persist despite all efforts at aquifer fitting because of incorrect identification of the reservoir drive mechanism. Initial assumptions about the reservoir drive mechanism are indirect. They are based on the pressure and production performance profiles of the reservoir and thus they carry room for revisions. Identification of reservoir drive mechanism is very important because it helps to refine the aquifer description and definition and also estimate the size of the initial gas cap. As in many cases, direct measured data of different aquifer parameters such as porosity, permeability, thickness, rock and fluid compressibilities were not available for Schaben field and these were inferred from those of the reservoir. Few logs penetrate the aquifer in this region and they used to estimate the height of the aquifer. The reservoir radius was calculated volumetrically and was found to be 7000 feet. The Carter-Tracy method was used for water influx calculations because it is the time-dependent aquifer modeling option available in the reservoir simulator BOAST3.

Material balance calculations require adequate field pressure and production profiles along with the PVT data of reservoir fluids. One method to determine the average field pressure is by volume weighting the shut-in pressures within the drainage area of each well. Regular recording of reservoir pressure at each well form the basis of material balance calculations. Unfortunately for Schaben field, there is no recorded history of pressure measurements carried out at individual wells. Only current operating water column heights are available for most of the wells. PVT data was generated from standard correlations. With limited pressure data available, it is impossible to obtain the average reservoir pressure through the life of the field. Thus, the material balance calculations in this study were used to generate the average reservoir pressure profile through the life of the field and also to check if the aquifer description and assumed drive mechanism could support the reported field performance data. This process necessitated the assumption that the OOIP reported from volumetric studies was adequate.

The initial volumetric calculations were carried out using the first nine years of production data and historically this was the period during which most of the field development took place. Yearly oil (N_p) and water (W_p) production data from Schaben field for the first 9 years is recorded in Table 3 along with the calculations for the underground volume withdrawal (F) of fluids. The Carter-Tracy formulation was used to calculate the water influx (W_e) from an infinite aquifer. Table 3 also shows the water influx calculations[2]. The aquifer parameters, assumed initially, were varied within geologic and engineering limits till the plot between F/E versus W_e/E showed as a straight line with unit slope (Figure 7) and with an intercept showing an OOIP value (36.7 MMSTB) that is lower (within 10%) but near the value calculated from volumetrics, i.e., 37.8 MMSTB. Aquifer properties that resulted in this match are tabulated in Table 3. The average reservoir pressure (for the first 9 years) as a result of this match is plotted as the "basecase" profile in Figure 8.

Several sensitivity calculations were carried out by varying different parameters such as aquifer height (Table 4), reservoir radius (Table 5), aquifer permeability (Table 6), and aquifer porosity (Table 7). In each instance, the value of only one of the above parameters was changed. The average reservoir pressure profile was generated, each time, by trial and error such that the resultant F/E versus W_e/E plot was a straight line with unit slope and its intercept read an OOIP value that was close and yet less (within 10%) than 37.8 MMSTB. The resultant pressure profiles, generated from each of the above cases, have been plotted in Figure 8 and it clearly indicates the results of varying different aquifer parameters and the reservoir radius. Available fluid level data indicate that in the majority of the wells the reservoir is currently producing against a backpressure varying between 400 to 1100 psi. A "bestcase" scenario was developed by modifying the assumptions of the "basecase" model by using the information from the above sensitivity studies. This scenario was developed to incorporate known facts such as the field operating under a strong water drive and that it is currently producing against a significant backpressure. The various aquifer and reservoir parameters used in the "bestcase" mass balance calculations are presented in Table 8. In this case, the calculations were carried over a period of 34 years. The average reservoir pressure profile (Figure 9) shows a rapid decline from 1370 psi to 1000 psi due to the production from the first 9 years. Thereafter, the reservoir pressure stabilized near 1000 psi for the next 14 years and then gradually declined to 880 psi over the next 11 years. Figure 10 shows the plot between F/E versus W_e/E for the "bestcase" scenario.

Output

Material balance study confirms that the volumetric description of the reservoir-aquifer system together with the natural water drive mechanism is able to support the reported fluid production history of the field. The above process of "aquifer-fitting" enabled in fine tuning some of the aquifer parameters such as its height, porosity, permeability, and effective compressibility, and also the reservoir radius. These parameters are all required in building an input file for reservoir simulation. Due to the non-availability of the average reservoir pressure profile for the Schaben field, the mass balance calculations could not be used to check the validity of the volumetric description of the reservoir. In this study, the volumetric OOIP was assumed to be correct and was used to calculate an average reservoir pressure profile. The reservoir pressure profile controls the PVT properties of the reservoir fluids and hence the mobility ratios operating during the production life of the field. The extent of the change in average reservoir pressure is indicative of the amount of change occurring in the fluid viscosities and this plays a critical role in reservoir simulation studies.

Material balance calculations are useful tools to check the coherency between different aspects of reservoir description. These calculations help to tie together the geomodel of the reservoir, the log analysis at individual wells, the mapping of petrophysical parameters, the PVT data and the profiles of field production and pressure. They also help to identify the reservoir drive mechanism and when applicable enable description of the aquifer and provide an initial volume estimate for the gas cap. This exercise assumes significance especially because all the above mentioned aspects of reservoir characterization comprise sections of the input file for a simulation study.

References:

1. Practice of Reservoir Engineering by L.P. Dake

2. $P(t_D)$ is the Carter-Tracy's constant terminal rate solution of the diffusivity equation and was calculated by using Franchi's regression coefficients[10], i.e., $P(tD) = a_o + a_1 t_D + a_2 \ln t_D + a_3(\ln t_D)^2$. The equation[10] stated below was applied to calculate the water influx W_e at the current time step j.

$$W_e(t_{Dj}) = W_e(t_{Dj-1}) + \frac{U\Delta P(t_{Dj}) - W_e(t_{Dj-1})P'(t_{Dj})}{P(t_{Dj}) - t_{Dj-1}P'(t_{Dj})}(t_{Dj} - t_{Dj-1})$$

The aquifer constant is expressed as $U = 1.119 f\phi h c r_o^2$ (bbl/psi) where f is fractional encroachment angle, h is the aquifer thickness in feet, r_o is the reservoir radius in feet, ϕ the fractional aquifer porosity, and the c the effective aquifer compressibility in psi^{-1}.

Bo is calculated using $B_o = B_{ob} EXP[c_o(P_b-P)]$ where B_{ob} (= 1.037 rb/stb) is the formation volume factor at bubble point, c_o (= 0.000005 psi^{-1}) is the oil compressibility and P_b is the bubble point pressure.

$\Delta P = P_i - P$, where P_i = 1370 psi.

$E = B_{oi} c_{eff} \Delta P$ where B_{oi} is the formation volume factor at P_i and c_{eff} is the effective reservoir compressibility.

$F = N_p B_o + W_p B_w$ where B_w (= 1.0117 rb/stb) is the formation volume factor for water at 1000 psi.

t_D = dimensionless time = $0.00634[kt/(\phi \mu c r_o^2)]$ where k is permeability in md, ϕ is fractional aquifer porosity, c is effective aquifer compressibility in psi^{-1}, r_o is the reservoir radius in feet, and t is time in days.

$P'(t_D)$ is the time derivative of the $P(t_D)$

Table 1											
No	**Name**	**API**	**Location**	**DST comments**	**DST from**	**DST to**	**Pi, psi**	**K, md**	**Prod from**	**Prod to**	**IP**
1	Moore B6	15-135-00479	30-19s-21w	FSIP - top	4415	4427	1340	1.5			
			w/2 NE NE	FSIP - bot			1346	1.5			
				ISIP - top	4427	4437	1350	8.5			
				FSIP - bot			1400	4.9			
				FSIP - top	4437	4447	1320	461.9	4436	4445	149 bopd, 1 bwpd
				FSIP - bot			1332	373.6			
2	Moore D2		30-19s-21w	ISIP	4365	4386	1380	4.7			
			sw C NW NW	FSIP	4386	4393	1334	179.4	4384	4390	153 bopd, tr wtr
3	Moore B4	99-000-00013	30-19s-21w	ISIP	4393	4402	1420	1.1			
			C NW NE	FSIP	4402	4412	1270	7.3			
				FSIP	4412	4422	1366	215.1	4408	4414	121 bopd, nw
4	Moore B5	99-000-00014	30-19s-21w	FSIP	4385	4395	1400	10.9	4388	4392	123 bopd, nw
			C SW NE	FSIP	4395	4405	1380	31.2			
5	Moore C3	15-135-21024	30-19s-21w	FSIP - top	4428	4438	1215	1.4	4416	4420	42 bopd, 90 bwpd
			C NE SW	FSIP - bot			1224	1.3	(outside DST range)		
				FSIP - top	4439	4446	1230	7.4			
				FSIP - bot			1220	7.4			
				FSIP - top	4446	4460	1270	1.1			
				FSIP - bot			1270	1.1			
6	Moore C2		30-19s-21w	ISIP	4402	4410	1395	41.8	4402	4406	184 bopd, 4% tr wtr
			C NW SW	FSIP			1500	3.1			
				FSIP	4410	4425	1312	65.5			
7	Moore B1		30-19s-21w	ISIP	4396	4410	1300	36.6			
			C SE SE	ISIP	4410	4420	1338	105.6	4401	4416	122 bopd, nw
				ISIP	4420	4430	1360	68.5			
				FSIP	4430	4440	1428	61.1			
8	Moore D3	15-135-30030	sw of C NE NW	ISIP	4381	4388	1390	2.8			
				FSIP	4388	4400	1390	4.5			
				FSIP	4400	4410	1378	63.9	4399	4403	121 bopd, nw
9	Moore D4	99-000-00018	C SE NW	FSIP top	4428	4436	1340	185.4	4421	4423	121 bopd, tr wtr
				FSIP bot			1340	193.5			
10	Humburg A2	99-000-00031	C SE SE	FSIP	4391	4401	1345	6.3	4393	4397	103 bopd, 2% wtr
				ISIP	4401	4411	1370	16.4			
11	Borger A1	99-000-00029	C SE NW	FSIP	4405	4412	1300	21.9	4405	4413.5	44 bopd, nw
12	Borger A2	15-135-30004	C NE NW	ISIP	4398	4410	1390	76.4	4394	4404	148 bopd, nw

Table 2A

No	Well	API	Code	Log	Rw	Rmf	Ros	Matrx	Flud-Mat	Phi 3%	Phi 40%	Perf	BVW	Sw	Gama	Comments
1	Wittman 1	1513530046	19-42	MLL	0.13	0.051	35%					4398-03	0.11	0.77	15	IP: 74 bopd, NW. 2 yrs - O>50bopd, w<10 bpd
2	Wittman 2	1513530066	19-41	MLL	0.13	0.05	35%					4392-10	0.138	0.56	na	IP: 10 bopd, 36% wtr. Well closed after a yr
																Log till 4394
3	Gneich 1	1513530022	19-43	Neu	0.13					1880	730	4380-93	0.108	0.78	15	IP: 102 bopd & 6% wtr. 2yrs - O>50bpd, w<10 bpd
																Log till 4386
																Super Pickett enabled selection of Phi3&40 cut offs
																Values lower than 1880 & 730 give too low porosity
4	Gneich 1	9900000001		Neu	0.13					1700	700	4425-35 dst	0.14	0.82	27	50' MCO & 20' WCM. D&A. Outside study area
5	Wilhelm C1	9900000003		Neu	0.13					2100	780	4445-50 dst	0.14	0.92	18	30' SMCGCO, 124' MO, & 62' OCM
												4450-55 dst	0.14	0.82	25	15' M
																D&A. outside study area
6	Rein A6	1513521023		DN	0.13							4448-60 dst	0.14	0.72	28	120' WM
												4461-76 dst	0.15	0.85	9	110' MW
																D&A.
7	Rein A4	1513591401	29-11	MLL	0.13	0.075	35%					4438-44	0.10	0.66		IP: 132 bopd, tr wtr. After 1 yr w = 50bpd (O=50bpd)
						0.055							0.1	0.77		
8	Rein A2	1513530031	29-41	MLL	0.13	0.058	35%					4394-00	0.095	0.63	17	IP: 132 bopd, nw. 1 yr for O 60 to 15 bpd & w 0 to 35bpd
9	Rein A5	1513520069	29-22	MLL	0.13	0.055	35%					4448-54	0.108	0.757	25	IP: 46 bopd & 1% wtr. 2 yrs - O 100 to 10 bpd
																and w 0 to 3.5 bpd. Log till 4452
10	Moore B1	9900000009	30-44	Sonic	0.13			44	145			4401-16	0.11	0.575	27	IP: 122 bopd & nw. 1st yr - O = 48bpd, W = 0 bpd
																2nd yr O = 39 bpd, W = 20 bpd
11	Moore B2	9900000011	30-33	MLL-S	0.13	0.07	35%	44	145			4400-01	0.097	0.512	31	IP: 20 bopd & 20% wtr. Produced 9 yrs - low fluid well
				MLL	0.13	0.07	35%							0.75		3 yrs for O 9.8 to 1.7 bpd & W 0 to 2.5 bpd
				Sonic	0.13			44	145					0.4		MLL plot - low phi & therefore K.
12	Moore D3	1513530030	30-12	MLL	0.13	0.06	35%						0.114	0.675	16.5	IP: 121 bopd & nw. 4 yrs - O close to 50bpd & w < 1bpd
						0.07	25%						0.114	0.721		Ros averaged from log 25%
13	Moore B5	9900000014	30-23	MLL	0.13	0.066	35%					4388-92	0.089	0.742	28.6	IP: 123 bopd & nw. 3 yrs - O 100 to 50 bpd, W - 0 to 20
																bpd.
14	Moore B4	9900000013	30-13	MLL	0.13	0.057	35%					4408-14	0.111	0.621	14	IP: 121 bopd & nw. 2 yrs - O > 40bpd, little wtr
																From 3rd yr - wtr comes in with a bang >50bpd
15	Moore D4	9900000018	30-22	MLL	0.13	0.056	30%					4421-23	0.099	0.662	13.6	IP: 121 bopd & tr wtr. 3 yrs - O>50bpd, W negligible
																4th yr - W 20bpd & O 48 bpd
16	Moore D1	1513500675	30-21	MLL	0.13	0.079	40%					4388-94	0.099	0.478	12.5	IP: 195 bopd, nw. 6 yrs - O>50bpd, W<3bpd
						0.06	35%							0.595		7th yr - w=12bpd & O=47bpd. Ros from log = 40%
17	Schaben A1	9900000021	31-13	MLL	0.13	0.065	20%						0.139	0.942	17	D&A well. Averaged 4422-4434.5 ft - where phi>0.1.
						0.065	30%							0.765		
18	Batt A1	9900000024	31-11	MLL/S	0.13	0.099	20%	44	145							D&A. Data 4450-90. BVW above .12

Table 2B																
No	**Well**	**API**	**Code**	**Log**	**Rw**	**Rmf**	**Ros**	**Matrx**	**Flud-Mat**	**Phi 3%**	**Phi 40%**	**Perf**	**BVW**	**Sw**	**Gama**	**Comments**
19	Gillig 1	1513523400	23-43	D/N	0.13							4385-93	0.119	0.59	34.6	Perf test results not reported. Converted to water
																injection well.
20	Schaben 1	1513521593		Sonic	0.13			44	145			4379-84	0.117	0.68	40	D&A. Little oil recovered after acid.
21	Borger A2	1513530004	25-12	MLL	0.13	0.075	35%					4394-04	0.105	0.64	n/a	IP: 148 bopd & NW. Yr1: O 63bpd, W <1bpd
						0.06	35%							0.69		Yr2: O 50bpd, W 50 bpd
22	Dora Wagner 1	9900000032	25-32	Sonic	0.13			44	145			4384-00	0.09	0.504	27	IP: 104 bopd, nw. By Yr2: O 64bpd, W 20 bpd
																Yr3: O 58 bpd & W 48bpd
23	Humburg A1	1513500323	25-34	MLL	0.13	0.087	35%					4393-4406				Log over Perf n/a. IP: 198 bopd nw. Till Yr2: O 36 bpd
																& W < 7 bpd. Yr3: O 36 bpd & W 20 bpd
												4379-94 dst	0.095	0.61	14.5	957' FO & 248' MO-nw
24	Humburg 1	9900000055	25-33	Sonic	0.13			44	145			4392-00	0.086	0.49	9.7	IP: 91 bopd, nw. Yr1: O 117 bpd, W 25 bpd
																Yr 2: 53 bpd W 25 bpd
25	Humburg A2	9900000031	25-44	MLL	0.13	0.075	40%					4393-97	0.076	0.77	29	IP: 103 bopd & 2% wtr. Yr1: O 21bpd, W 0 bpd
						0.065	35%							0.89		Yr2: O 19 bpd, W 3 bpd. Yr3: O 19 bpd, W 10 bpd
26	Borger A1	9900000029	25-22	MLL	0.13	0.06	35%					4405-13.5	0.122	0.749		IP: 44 bopd, nw. Till 8 yrs - O avg 24bpd and W < 7 bpd
																Yr 9: O 22bpd & W 52 bpd
27	Dora Wagner 3	9900000034	25-42	MLL	0.13	0.06	35%					4386-01	0.123	0.714		log till 4396. IP: 73 bpd & 15% wtr. Yr1: O 34.4bpd
																W 6.1 bpd. Yr2: O 19.7 bpd, 9.3 bpd. Yr3: O 37bpd
																W 157.7 bpd
28	Borger 1	1513523399	25-21	DN	0.13							4380-88	0.092	0.482	39	IP: 15 bopd and nw. Yr O 142bpd, W 31 bpd.
																Yr2 O 51bpd W 45 bpd. Prod commingled
																with twin wells. Significant W prod thru out.
29	Dora Wagner 2	9900000033		Sonic	0.13			44	145			4382-02	0.108	0.665	33	D&A. Acid, fractured and squeeze cemented.
																Possibly drilling complications affected producibility.
30	Robert B Lent 1	1513530251	26-24	Sonic	0.13			44	145			4390-96	0.14	0.66	33	IP: 90bopd & tr wtr. Yr1 O 11.5bpd W 0bpd. Yr2 O 19.8
																W 3.5. Yr4 O 10.4 W 12.7
31	Robert B Lent 2	1513530308	26-14	Sonic	0.13			44	145			4383-93	0.092	0.54	43	Tested dry. D&A. Probably due to high gamma
32	HL Williams Est 2	9900000037	36-14	Sonic	0.13			44	145			4423-43 dst	0.137	0.726	38	D&A.
33	HL Williams Est 1	9900000060	36-13	Sonic	0.13			44	145			4363-75	0.092	0.487	49.6	IP: 120 bpd nw. Yr1 O 19.7bpd W 0bpd. Yr2 O 19.7 bpd
																W 3.5bpd. Yr3 O 19.7bpd & W 10.6bpd
34	Moore C3	1513520124	30-32	D/N	0.13							4416-20	0.095	0.48	44	IP: 42 bopd, 90 bwpd. Yr1 O 34bpd, W 1.8bpd, Yr2 O 18bpd,
												(avg from 4417.5 to 20)				W 3.8bpd, Yr3 O 8.9bpd, W 3.8bpd. Yr4 7.4 bpd, W 26bpd
																ILD readings not legible between 4416-20 - only traces visible
												4428-36 dst	0.108	0.602	21	40' O, 20' OCM, 60' OCMW
35	Out on Bail 1	1513522108	24-43	D/N	0.13							4393-15 dst	0.14	0.83	22	D&A. DST recovery n/a.
36	Anna Williams 5	1513522275		D/N	0.13							4371-78	0.09	0.59	53.7	Well D&A. Upper perf P 2 bopd & 445 bwpd. Very high gamma
													0.12	0.7	19.5	Lower perf uncommercial
37	Lyle Schaben 2P	1513523925	31-14	D/N	0.13							4400-04	0.105	0.59	17	IP: 53 bopd & 97 bwpd

Table 3

Material Balance & Carter-Tracy water influx calculation: Base Case

Carter-Tracy Inputs: Avg. Aquifer Properties

K	25 md	Aq. K
phi	0.25	Aq. Phi
mu	0.67 cp	Aq. Water
C	0.00000674 1/psi	Aq. Eff. C
Ro	5725.00 ft	Res. Radius
f	1	
h	100 ft	Aq. Height

tD = 0.00634*k*t/(phi*mu*c*Ro^2)

U=1.119*f*phi*h*c*Ro^2

U = 6179.893257

U nearly = ***6179.893257*** b/psi

tD multiplier= ***0.00428355***

Underground withdrawal calculation

Time	Np	Wp	P	Bo	del P	E	F	F/E
Days	stb	stb	psi	rb/stb		rb/stb	rb	MMstb
	0	0	1370.00					
365	26000	6000	1366.88	1.031096	3.12	3.7599E-05	32879	874.46
730	220000	32000	1347.65	1.031195	22.35	0.00026934	259237	962.50
1095	682000	113000	1308.00	1.0314	62	0.00074716	817737	1094.46
1460	1252000	411000	1261.00	1.031642	109	0.00131355	1707425	1299.86
1825	1769000	963000	1223.60	1.031835	146.4	0.00176425	2799584	1586.84
2190	2226000	1946000	1164.50	1.03214	205.5	0.00247646	4266312	1722.74
2555	2675000	3557000	1068.70	1.032635	301.3	0.00363094	6360915	1751.86
2920	3066000	5663000	990.00	1.033041	380	0.00457935	8896561	1942.76
3285	3424000	8056000	930.60	1.033348	439.4	0.00529517	11688438	2207.38

WaterInflux calculation

Time									**F/E**	**N**	**F**
Days	**tD**	**P(tD)**	**P'(tD)**	**Pr.**	**del Pr.**	**We, bbl**	**We, MMbl**	**We/E,MMS**	**MMStb**	**MMstb**	**MRB**
	0	0		1370.00		0					
365	1.5635	0.9553	0.6110	1366.88	3	31556.819	0.0316	839	874.46	35	33
730	3.1270	1.1868	0.1481	1347.65	22	249965.553	0.2500	928	962.50	34	259
1095	4.6905	1.3348	0.0947	1308.00	62	791040.805	0.7910	1059	1094.46	36	818
1460	6.2540	1.4454	0.0707	1261.00	109	1658208.88	1.6582	1262	1299.86	37	1707
1825	7.8175	1.5344	0.0569	1223.60	146	2733278.36	2.7333	1549	1586.84	38	2800
2190	9.3810	1.6091	0.0478	1164.50	206	4175054.33	4.1751	1686	1722.74	37	4266
2555	10.9445	1.6736	0.0413	1068.70	301	6228836	6.2288	1715	1751.86	36	6361
2920	12.5080	1.7306	0.0364	990.00	380	8719195.49	8.7192	1904	1942.76	39	8897
3285	14.0715	1.7816	0.0326	930.60	439	11486533.6	11.4865	2169	2207.38	38	11688
									Average MB N=	**36.7**	
									Volumetric N=	**37.8**	

Table 4

Material Balance & Carter-Tracy water influx calculation: Aquifer height = 125 ft.

K	25	md	Aq. K
phi	0.25		Aq. Phi
mu	0.67	cp	Aq. Water
C	0.00000674	1/psi	Aq. Eff. C
Ro	5725.00	ft	Res. Radius
f	1		
h	125	ft	Aq. Height

Aquifer height = 125 ft.

tD = 0.00634*k*t/(phi*mu*c*Ro^2)
U=1.119*f*phi*h*c*Ro^2
U = 7724.866571
U nearly = ***7724.866571*** b/psi
tD multiplier= ***0.0043***

Underground withdrawal calculation

Time	Np	Wp	P	Bo	del P	E	F	F/E
Days	stb	stb	psi	rb/stb		rb/stb	rb	MMstb
	0	0	1370.0					
365	26000	6000	1367.5	1.031093	2.52	3.0368E-05	32879	1082.66
730	220000	32000	1352.0	1.031173	18	0.00021692	259232	1195.08
1095	682000	113000	1320.0	1.031338	50	0.00060255	817695	1357.07
1460	1252000	411000	1282.0	1.031534	88	0.00106048	1707289	1609.92
1825	1769000	963000	1252.5	1.031686	117.5	0.00141598	2799320	1976.94
2190	2226000	1946000	1204.6	1.031933	165.4	0.00199322	4265851	2140.18
2555	2675000	3557000	1127.7	1.03233	242.3	0.00291994	6360100	2178.16
2920	3066000	5663000	1064.0	1.032659	306	0.00368758	8895389	2412.26
3285	3424000	8056000	1020.0	1.032886	350	0.00421782	11686857	2770.83

WaterInflux calculation

Time									**F/E**	**N**	**F**
Days	**tD**	**P(tD)**	**P'(tD)**	**Pr.**	**del Pr.**	**We, bbl**	**We, MMbl**	**We/E,MM**	**MMStb**	**MMstb**	**MRB**
0	0	0		1370.00		0					
365	1.5635	0.9553	0.6110	1367.48	3	31860.25	0.0319	1049	1082.66	34	33
730	3.1270	1.1868	0.1481	1352.00	18	251712.607	0.2517	1160	1195.08	35	259
1095	4.6905	1.3348	0.0947	1320.00	50	797189.67	0.7972	1323	1357.07	34	818
1460	6.2540	1.4454	0.0707	1282.00	88	1672423.49	1.6724	1577	1609.92	33	1707
1825	7.8175	1.5344	0.0569	1252.50	118	2750314.36	2.7503	1942	1976.94	35	2799
2190	9.3810	1.6091	0.0478	1204.60	165	4200835.46	4.2008	2108	2140.18	33	4266
2555	10.9445	1.6736	0.0413	1127.70	242	6265154.36	6.2652	2146	2178.16	33	6360
2920	12.5080	1.7306	0.0364	1064.00	306	8772097.11	8.7721	2379	2412.26	33	8895
3285	14.0715	1.7816	0.0326	1020.00	350	11524102.9	11.5241	2732	2770.83	39	11687
									Average N=	**34.1**	
									Vol. N=	**37.8**	

Table 5

Material Balance & Carter-Tracy water influx calculation: Reservoir radius = 8000 ft.

Carter-Tracy Inputs:

K	25	md	Aq. K
phi	0.25		Aq. Phi
mu	0.67	cp	Aq. Water
C	0.00000674	1/psi	Aq. Eff. C
Ro	8000.00	ft	Res. Radius
f	1		
h	100	ft	Aq. Height

Reservoir radius = 8000 ft.

tD = 0.00634*k*t/(phi*mu*c*Ro^2)
U=1.119*f*phi*h*c*Ro^2
U = 12067.296
U nearly = ***12067.296*** b/psi
tD multiplier= ***0.0022***

Underground withdrawal calculation

Time Days	Np stb	Wp stb	P psi	Bo rb/stb	del P	E rb/stb	F rb	F/E MMstb
	0	0	1370.0					
365	26000	6000	1367.5	1.031093	2.5	3.0127E-05	32879	1091.32
730	220000	32000	1352.1	1.031172	17.9	0.00021571	259232	1201.76
1095	682000	113000	1319.6	1.03134	50.4	0.00060737	817696	1346.30
1460	1252000	411000	1280.7	1.031541	89.3	0.00107615	1707298	1586.49
1825	1769000	963000	1249.5	1.031702	120.5	0.00145214	2799347	1927.75
2190	2226000	1946000	1201.0	1.031952	169	0.0020366	4265893	2094.61
2555	2675000	3557000	1120.0	1.03237	250	0.00301273	6360206	2111.11
2920	3066000	5663000	1054.0	1.032711	316	0.00380809	8895548	2335.96
3285	3424000	8056000	1005.0	1.032964	365	0.00439858	11687122	2657.02

WaterInflux calculation

Time **Days**	**tD**	**P(tD)**	**P'(tD)**	**Pr.**	**del Pr.**	**We, bbl**	**We, MMbl**	**We/E,MMS**	**F/E** **MMStb**	**N** **MMstb**	**F** **MRB**
	0	0		1370.0		0					
365	0.8007	0.7578	0.9464	1367.5	3	31876.1736	0.0319	1058	1091.32	33	33
730	1.6014	0.9628	0.2561	1352.1	18	251484.416	0.2515	1166	1201.76	36	259
1095	2.4021	1.0955	0.1657	1319.6	50	797889.057	0.7979	1314	1346.30	33	818
1460	3.2028	1.1953	0.1246	1280.7	89	1672086.14	1.6721	1554	1586.49	33	1707
1825	4.0035	1.2759	0.1007	1249.5	121	2751868.9	2.7519	1895	1927.75	33	2799
2190	4.8042	1.3439	0.0849	1201.0	169	4191876.34	4.1919	2058	2094.61	36	4266
2555	5.6049	1.4027	0.0736	1120.0	250	6258525.64	6.2585	2077	2111.11	34	6360
2920	6.4056	1.4548	0.0651	1054.0	316	8760095.18	8.7601	2300	2335.96	36	8896
3285	7.2063	1.5016	0.0584	1005.0	365	11524684.8	11.5247	2620	2657.02	37	11687
									Average N=	**34.4**	
									Vol. N=	**37.8**	

Table 6

Material Balance & Carter-Tracy water influx calculation: Aquifer K = 40 md

Carter-Tracy Inputs:

K	40	md	Aq. K
phi	0.25		Aq. Phi
mu	0.67	cp	Aq. Water
C	0.00000674	1/psi	Aq. Eff. C
Ro	5725.00	ft	Res. Radius
f	1		
h	100	ft	Aq. Height

Aquifer K = 40 md.

tD = 0.00634*k*t/(phi*mu*c*Ro^2)
U=1.119*f*phi*h*c*Ro^2
U = 6179.893257
U nearly = *6179.893257* b/psi
tD multiplier= ***0.0069***

Underground withdrawal calculation

Time	Np	Wp	P	Bo	del P	E	F	F/E
Days	stb	stb	psi	rb/stb		rb/stb	rb	MMstb
	0	0	1370.0					
365	26000	6000	1367.7	1.031092	2.29	2.7597E-05	32879	1191.40
730	220000	32000	1353.6	1.031164	16.36	0.00019715	259231	1314.87
1095	682000	113000	1324.9	1.031313	45.1	0.0005435	817677	1504.48
1460	1252000	411000	1291.4	1.031485	78.6	0.0009472	1707228	1802.39
1825	1769000	963000	1265.0	1.031622	105	0.00126535	2799206	2212.21
2190	2226000	1946000	1223.5	1.031836	146.5	0.00176546	4265634	2416.16
2555	2675000	3557000	1155.0	1.032189	215	0.00259095	6359723	2454.59
2920	3066000	5663000	1100.0	1.032473	270	0.00325375	8894819	2733.72
3285	3424000	8056000	1059.0	1.032685	311	0.00374784	11686168	3118.11

WaterInflux calculation

Time									**F/E**	**N**	**F**
Days	**tD**	**P(tD)**	**P'(tD)**	**Pr.**	**del Pr.**	**We, bbl**	**We, MMbl**	**We/E,MMS**	**MMStb**	**MMstb**	**MRB**
	0	0		1370.00		0					
365	2.5016	1.1093	0.4434	1367.71	2	31914.3281	0.0319	1156	1191.40	35	33
730	5.0032	1.3592	0.0999	1353.64	16	252723.023	0.2527	1282	1314.87	33	259
1095	7.5048	1.5179	0.0634	1324.90	45	800070.437	0.8001	1472	1504.48	32	818
1460	10.0064	1.6359	0.0472	1291.40	79	1674374.62	1.6744	1768	1802.39	35	1707
1825	12.5080	1.7306	0.0378	1265.00	105	2757791.72	2.7578	2179	2212.21	33	2799
2190	15.0096	1.8099	0.0317	1223.50	147	4205461.27	4.2055	2382	2416.16	34	4266
2555	17.5111	1.8783	0.0273	1155.00	215	6273834.14	6.2738	2421	2454.59	33	6360
2920	20.0127	1.9385	0.0241	1100.00	270	8776458.19	8.7765	2697	2733.72	36	8895
3285	22.5143	1.9924	0.0215	1059.00	311	11552889.3	11.5529	3083	3118.11	36	11686
									Average N=	**34.1**	
									Vol. N=	**37.8**	

Table 7

Material Balance & Carter-Tracy water influx calculation: Aquifer phi = 0.3

Carter-Tracy Inputs:

K	25	md	Aq. K
phi	0.3		Aq. Phi
mu	0.67	cp	Aq. Water
C	0.00000674	1/psi	Aq. Eff. C
Ro	5725.00	ft	Res. Radius
f	1		
h	100	ft	Aq. Height

Aquifer phi = 0.3

tD = 0.00634*k*t/(phi*mu*c*Ro^2)
U=1.119*f*phi*h*c*Ro^2
U = 7415.871909
U nearly = ***7415.87*** b/psi
tD multiplier= ***0.0036***

Underground withdrawal calculation

Time	Np	Wp	P	Bo	del P	E	F	F/E
Days	stb	stb	psi	rb/stb		rb/stb	rb	MMstb
	0	0	1370.00					
365	26000	6000	1367.05	1.031095	2.95	3.555E-05	32879	924.85
730	220000	32000	1348.90	1.031189	21.1	0.00025427	259236	1019.51
1095	682000	113000	1311.30	1.031383	58.7	0.00070739	817725	1155.98
1460	1252000	411000	1266.40	1.031614	103.6	0.00124848	1707390	1367.58
1825	1769000	963000	1231.00	1.031797	139	0.00167508	2799516	1671.28
2190	2226000	1946000	1174.00	1.032091	196	0.00236198	4266203	1806.20
2555	2675000	3557000	1084.00	1.032556	286	0.00344656	6360703	1845.52
2920	3066000	5663000	1005.00	1.032964	365	0.00439858	8896323	2022.54
3285	3424000	8056000	951.00	1.033243	419	0.00504933	11688078	2314.78

WaterInflux calculation

					Carter-Tracy cal.						
Time									**F/E**	**N**	**F**
Days	**tD**	**P(tD)**	**P'(tD)**	**Pr.**	**del Pr.**	**We, bbl**	**We, MMbl**	**We/E,MMS**	**MMStb**	**MMstb**	**MRB**
	0	0		1370.00		0					
365	1.3029	0.8989	0.6900	1367.05	3	31707.6562	0.0317	892	924.85	33	33
730	2.6058	1.1233	0.1722	1348.90	21	250586.037	0.2506	985	1019.51	34	259
1095	3.9087	1.2671	0.1104	1311.30	59	792877.349	0.7929	1121	1155.98	35	818
1460	5.2116	1.3748	0.0826	1266.40	104	1663443.26	1.6634	1332	1367.58	35	1707
1825	6.5146	1.4615	0.0665	1231.00	139	2738918.82	2.7389	1635	1671.28	36	2800
2190	7.8175	1.5344	0.0559	1174.00	196	4186977.05	4.1870	1773	1806.20	34	4266
2555	9.1204	1.5974	0.0484	1084.00	286	6237103.1	6.2371	1810	1845.52	36	6361
2920	10.4233	1.6531	0.0427	1005.00	365	8753609.16	8.7536	1990	2022.54	32	8896
3285	11.7262	1.7029	0.0383	951.00	419	11523679	11.5237	2282	2314.78	33	11688
									Average N=	**34.2**	
									Vol. N=	**37.8**	

Table 8

Material Balance & Carter-Tracy water influx calculation: Best Case - 35 years

Carter-Tracy Inputs:

K	30	md	Aq. K
phi	0.25		Aq. Phi
mu	0.67	cp	Aq. Water
C	0.00000674	1/psi	Aq. Eff. C
Ro	7000.00	ft	Res. Radius
f	1		
h	100	ft	Aq. Height

tD = 0.00634*k*t/(phi*mu*c*Ro^2)
U=1.119*f*phi*h*c*Ro^2
U = 9239.0235
U nearly = ***9239.02*** b/psi
tD multiplier= ***0.0034***

Bob (@ bubble point) =1.037 rb/stb

Bw = 1.0117 rb/stb @ 1000 psi

Average N= **34.97**
Vol. N= **37.8**

Underground withdrawal calculations

Time Days	Np, stb	Wp, stb	P psi	Bo rb/stb	del P	E rb/stb	F rb	F/E MMstb
0	0	0	**1370.00**					
365	26000	6000	1367.56	1.031093	2	2.9404E-05	32879	1118.16
730	220000	32000	1352.55	1.03117	17	0.00021029	259232	1232.74
1095	682000	113000	1321.50	1.03133	49	0.00058447	817689	1399.03
1460	1252000	411000	1284.20	1.031523	86	0.00103397	1707275	1651.19
1825	1769000	963000	1255.00	1.031673	115	0.00138586	2799297	2019.91
2190	2226000	1946000	1208.50	1.031913	162	0.00194622	4265807	2191.84
2555	2675000	3557000	1133.00	1.032303	237	0.00285607	6360027	2226.85
2920	3066000	5663000	1070.00	1.032628	300	0.00361528	8895294	2460.48
3285	3424000	8056000	1025.00	1.03286	345	0.00415757	11686769	2810.96
3650	3734000	10366000	1022.00	1.032876	348	0.00419372	14344040	3420.36
4015	3993000	12639000	1017.00	1.032902	353	0.00425397	16911252	3975.40
4380	4223000	14833000	1019.00	1.032891	351	0.00422987	19368446	4578.97
4745	4431000	16757000	1047.00	1.032747	323	0.00389245	21529157	5531.01
5110	4617000	18822000	1024.00	1.032865	346	0.00416962	23810957	5710.59
5475	4782000	21095000	992.00	1.033031	378	0.00455525	26281764	5769.56
5840	4925000	23228000	1005.00	1.032964	365	0.00439858	28587113	6499.16
6205	5058000	25558000	975.00	1.033119	395	0.00476011	31082542	6529.79
6570	5182000	27311000	1043.00	1.032767	327	0.00394065	32982339	8369.77
6935	5302000	29157000	1030.00	1.032834	340	0.00409731	34974225	8535.90
7300	5408000	31302000	989.00	1.033046	381	0.0045914	37254947	8114.07
7665	5480000	33212000	1017.00	1.032902	353	0.00425397	39260881	9229.23
8030	5536000	34931000	1042.00	1.032772	328	0.0039527	41057121	10387.11
8395	5631000	37266000	952.00	1.033237	418	0.00503728	43520172	8639.61
8760	5728000	39541000	949.00	1.033253	421	0.00507344	45922102	9051.48
9125	5814000	41586000	979.00	1.033098	391	0.00471191	48078987	10203.72
9490	5907000	43805000	950.00	1.033248	420	0.00506139	50420913	9961.88
9855	6019000	46614000	859.00	1.033718	511	0.00615802	53381332	8668.59
10220	6112000	48816000	941.00	1.033294	429	0.00516984	55702641	10774.53
10585	6222000	51054000	931.00	1.033346	439	0.00529035	58080810	10978.63
10950	6325000	53146000	950.00	1.033248	420	0.00506139	60303100	11914.35
11315	6413000	55819000	863.00	1.033697	507	0.00610981	63101183	10327.84
11680	6504000	58648000	832.00	1.033857	538	0.00648339	66058391	10188.86
12045	6591000	61219000	866.00	1.033682	504	0.00607366	68748259	11319.08

Water Influx calculations

Time Days	**tD**	**P(tD)**	**P'(tD)**	**Avg. Rese**	**del Pr.**	**We, bbl**	**We, MMbl**	**We/E,MMS**	**F/E MMStb**	**N MMstb**	**F MRB**
0	0	0		1370.00		0					
365	1.2550	0.8876	0.7073	1367.56	2	31873.6912	0.0319	1084	1118.16	34	33
730	2.5099	1.1104	0.1776	1352.55	17	251820.868	0.2518	1198	1232.74	35	259
1095	3.7649	1.2534	0.1139	1321.50	49	795870.044	0.7959	1362	1399.03	37	818
1460	5.0199	1.3605	0.0853	1284.20	86	1671094.57	1.6711	1616	1651.19	35	1707
1825	6.2748	1.4467	0.0687	1255.00	115	2750496.02	2.7505	1985	2019.91	35	2799
2190	7.5298	1.5192	0.0578	1208.50	162	4196935.01	4.1969	2156	2191.84	35	4266
2555	8.7848	1.5820	0.0500	1133.00	237	6257871.32	6.2579	2191	2226.85	36	6360
2920	10.0397	1.6373	0.0441	1070.00	300	8763991.44	8.7640	2424	2460.48	36	8895
3285	11.2947	1.6870	0.0396	1025.00	345	11528017.8	11.5280	2773	2810.96	38	11687
3650	12.5497	1.7320	0.0359	1022	348	14178072.2	14.1781	3381	3420.36	40	14344
4015	13.8046	1.7733	0.0329	1017.00	353	16756085.8	16.7561	3939	3975.40	36	16911
4380	15.0596	1.8113	0.0303	1019	351	19220506.6	19.2205	4544	4578.97	35	19368
4745	16.3146	1.8467	0.0282	1047.00	323	21375701.5	21.3757	5492	5531.01	39	21529
5110	17.5695	1.8798	0.0263	1024	346	23655017.9	23.6550	5673	5710.59	37	23811
5475	18.8245	1.9108	0.0247	992.00	378	26126397	26.1264	5735	5769.56	34	26282
5840	20.0795	1.9400	0.0233	1005	365	28436269.1	28.4363	6465	6499.16	34	28587
6205	21.3345	1.9677	0.0220	975.00	395	30923481.2	30.9235	6496	6529.79	33	31083
6570	22.5894	1.9939	0.0209	1043	327	32848783.5	32.8488	8336	8369.77	34	32982
6935	23.8444	2.0189	0.0199	1030.00	340	34838034.9	34.8380	8503	8535.90	33	34974
7300	25.0994	2.0427	0.0190	989	381	37094309.4	37.0943	8079	8114.07	35	37255
7665	26.3543	2.0655	0.0181	1017.00	353	39111808.1	39.1118	9194	9229.23	35	39261
8030	27.6093	2.0873	0.0174	1042	328	40922439.4	40.9224	10353	10387.11	34	41057
8395	28.8643	2.1082	0.0167	952.00	418	43344062.3	43.3441	8605	8639.61	35	43520
8760	30.1192	2.1284	0.0161	949	421	45751312.2	45.7513	9018	9051.48	34	45922
9125	31.3742	2.1478	0.0155	979.00	391	47918711.7	47.9187	10170	10203.72	34	48079
9490	32.6292	2.1665	0.0149	950	420	50257639.1	50.2576	9930	9961.88	32	50421
9855	33.8841	2.1846	0.0144	859.00	511	53183308.7	53.1833	8636	8668.59	32	53381
10220	35.1391	2.2020	0.0139	941	429	55521029.7	55.5210	10739	10774.53	35	55703
10585	36.3941	2.2189	0.0135	931.00	439	57899354	57.8994	10944	10978.63	34	58081
10950	37.6490	2.2353	0.0131	950	420	60127059.7	60.1271	11880	11914.35	35	60303
11315	38.9040	2.2512	0.0127	863.00	507	62901539.4	62.9015	10295	10327.84	33	63101
11680	40.1590	2.2667	0.0123	832	538	65847136	65.8471	10156	10188.86	33	66058
12045	41.4139	2.2817	0.0120	866.00	504	68542494.2	68.5425	11285	11319.08	34	68748

Well locations - Schaben Field, Ness County, Kansas

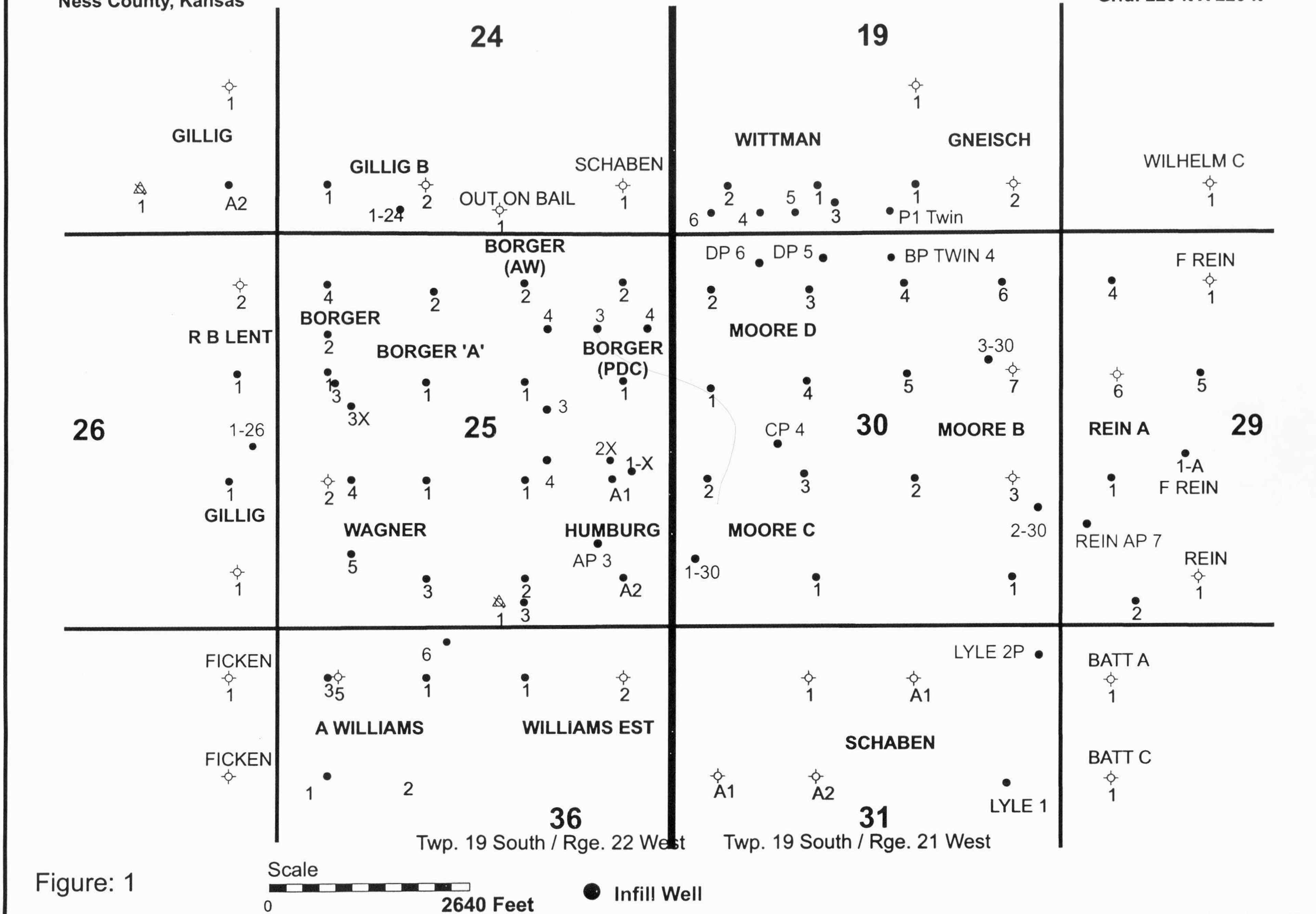


Figure: 1

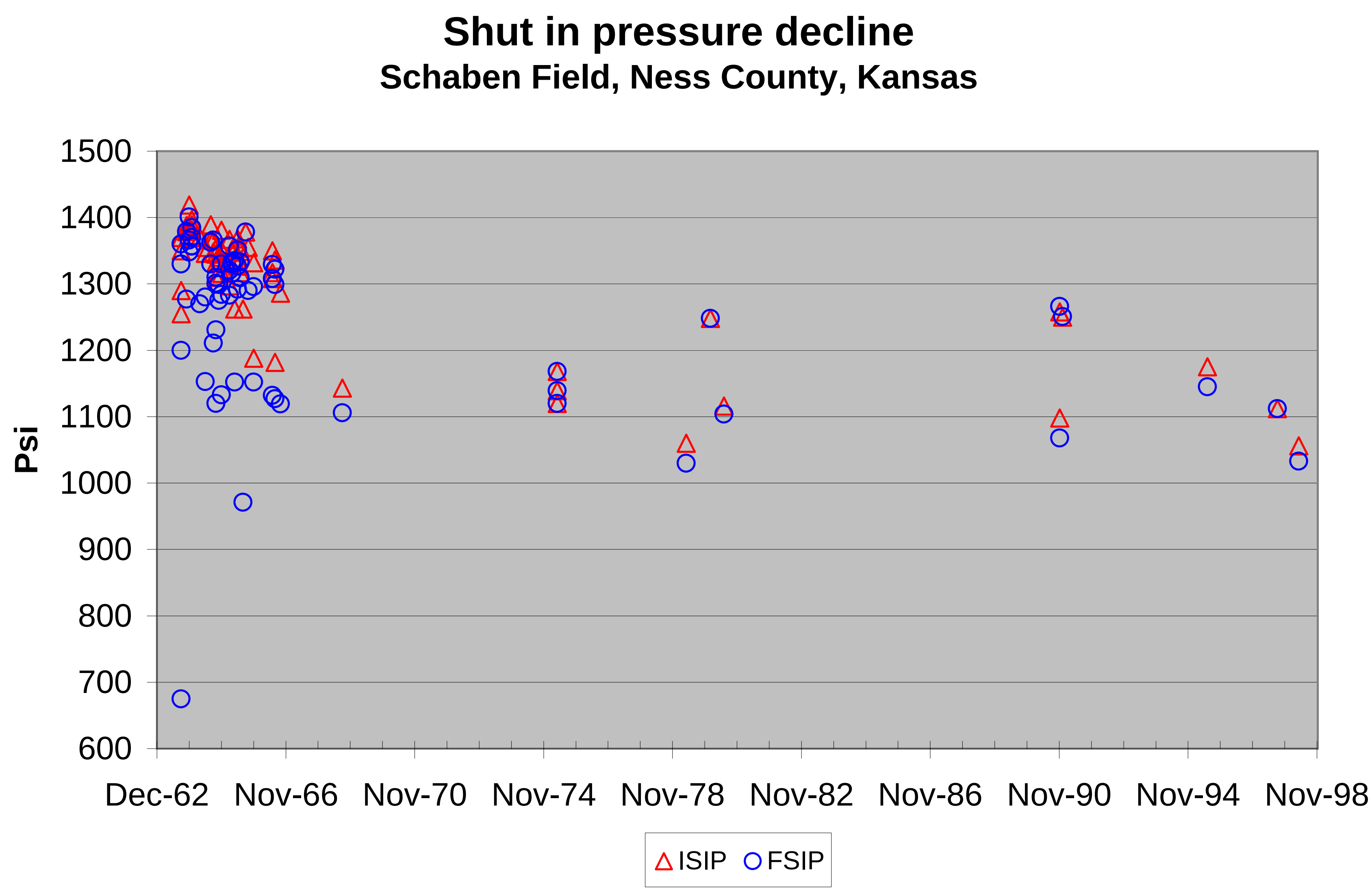


Figure: 2

Maximum shut-in pressure recorded 1410 psi (Dec 1963)

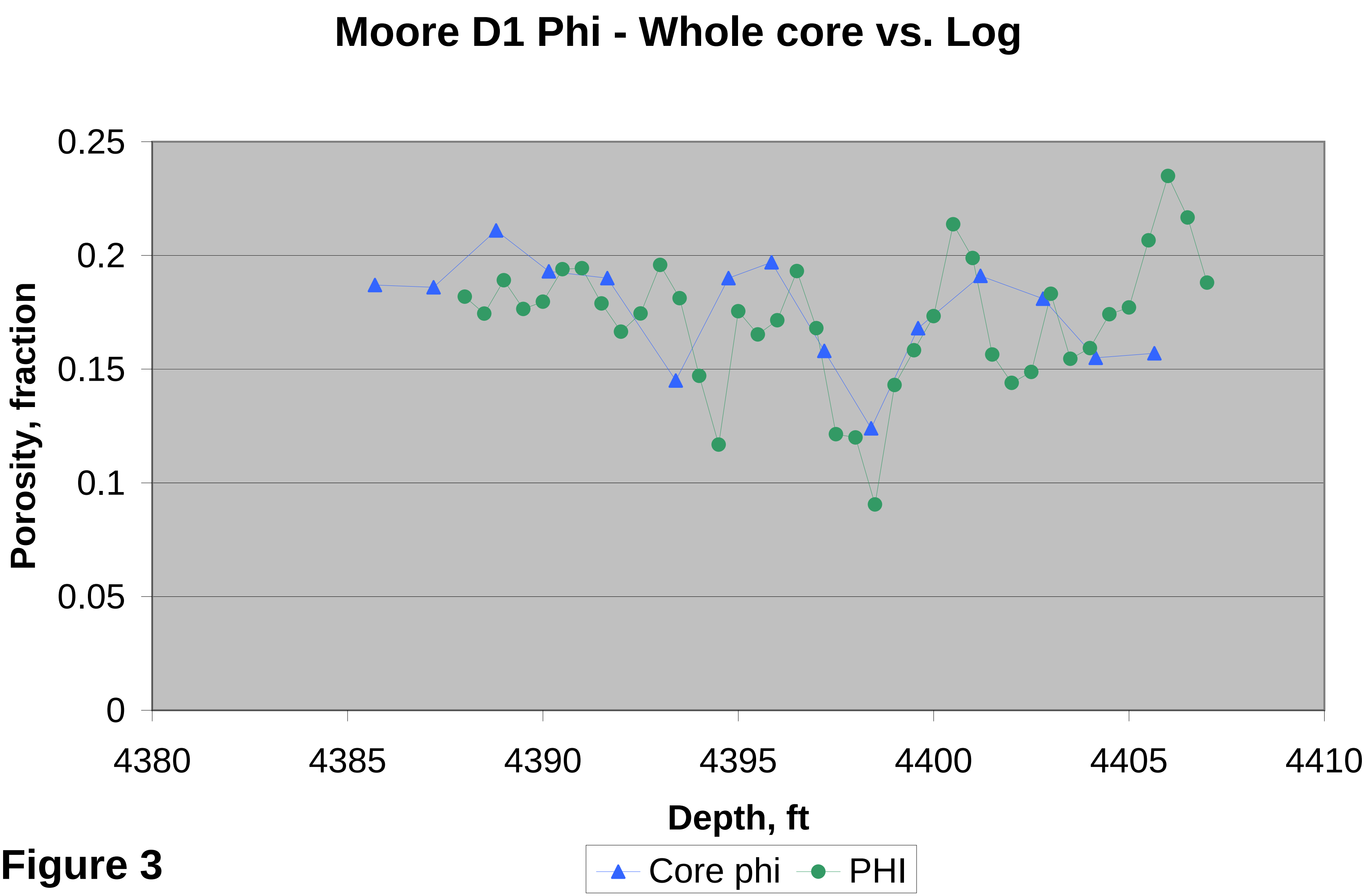

Moore D1 Phi - Whole core vs. Log
Porosity, fraction
0.25
0.2
0.15
0.1
0.05
0
4380
4385
4390
4395
4400
4405
4410
Depth, ft
Core phi
PHI

Figure 3

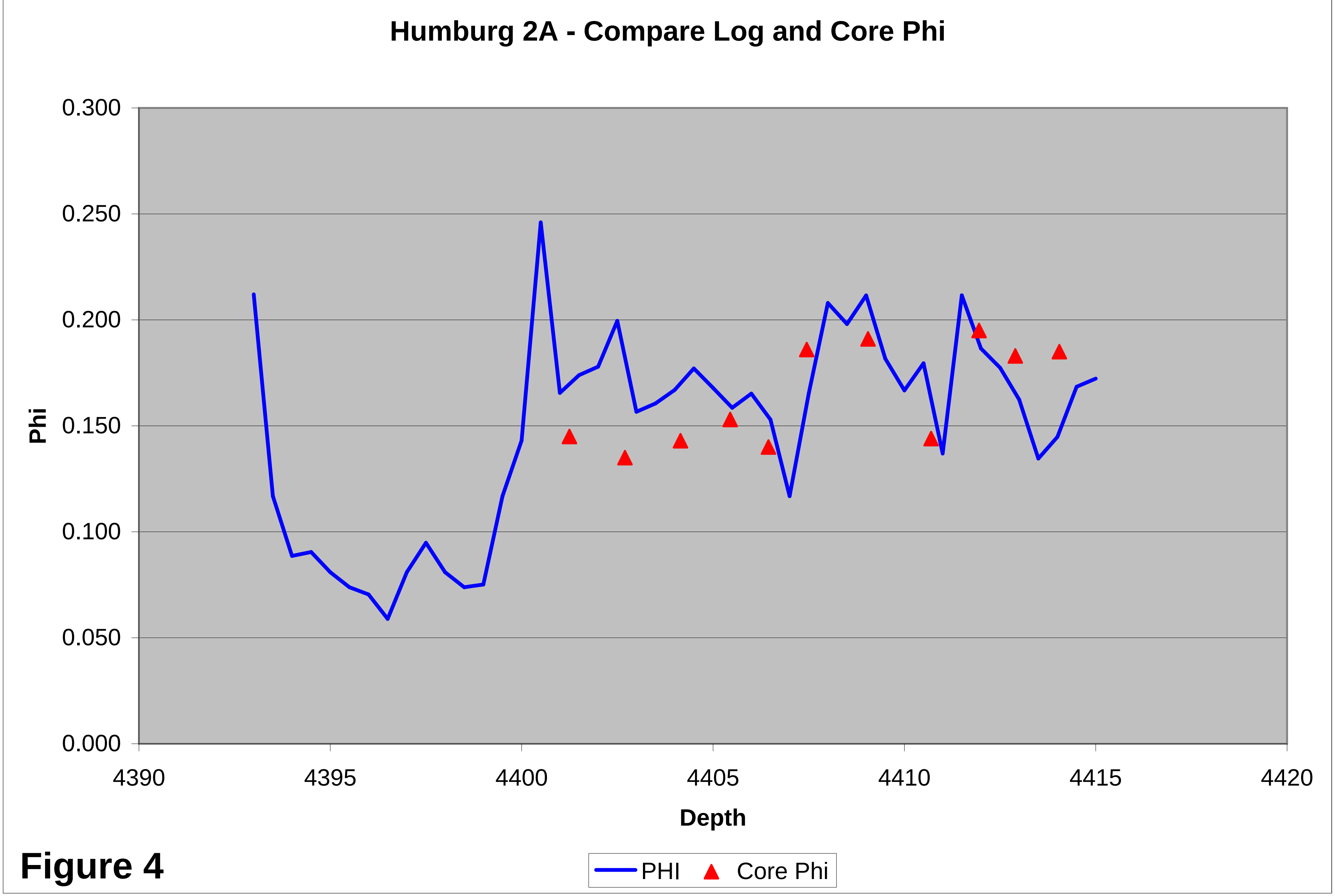

Humburg 2A - Compare Log and Core Phi
Phi
0.300
0.250
0.200
0.150
0.100
0.050
0.000
4390
4395
4400
4405
4410
4415
4420
Depth
PHI
Core Phi

Figure 4

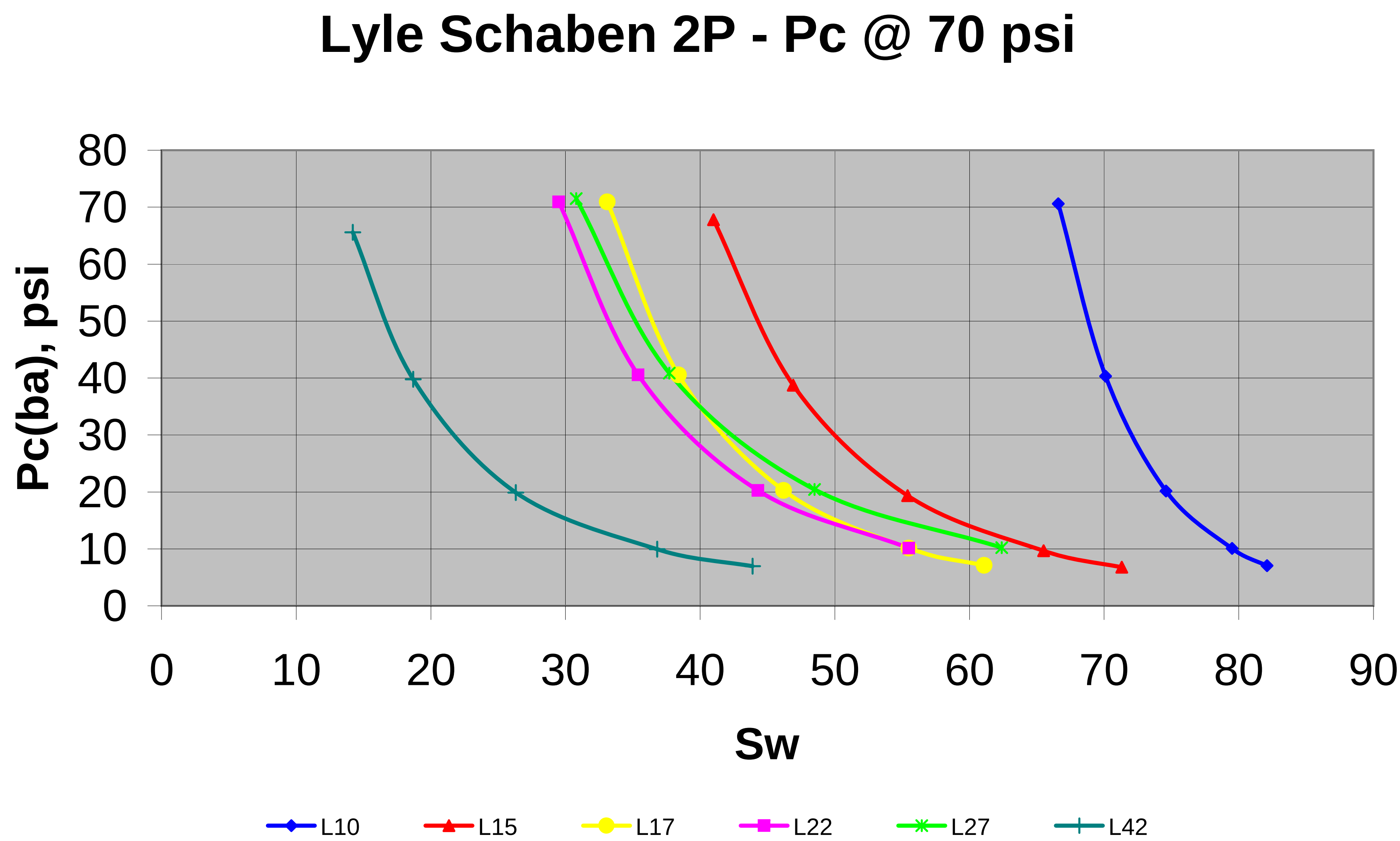
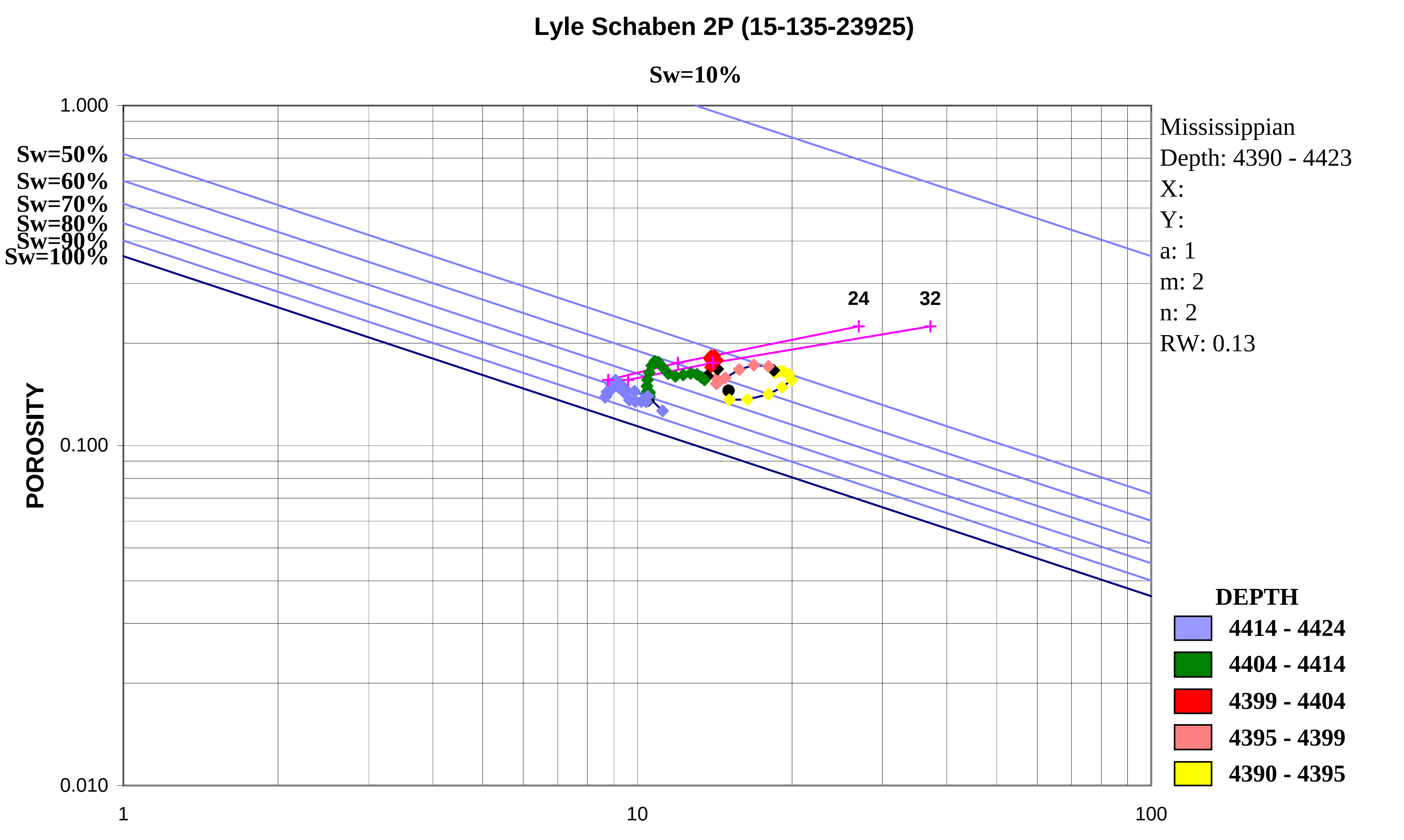

Lyle Schaben 2P - Pc @ 70 psi
Pc(ba), psi
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80
90
Sw
L10
L15
L17
L22
L27
L42

Figure: 5



Perf 4400-04: 53 bopd & 97 bwpd

Capillary pressure mapped: data from samples #10, 15, & 42

Figure 6

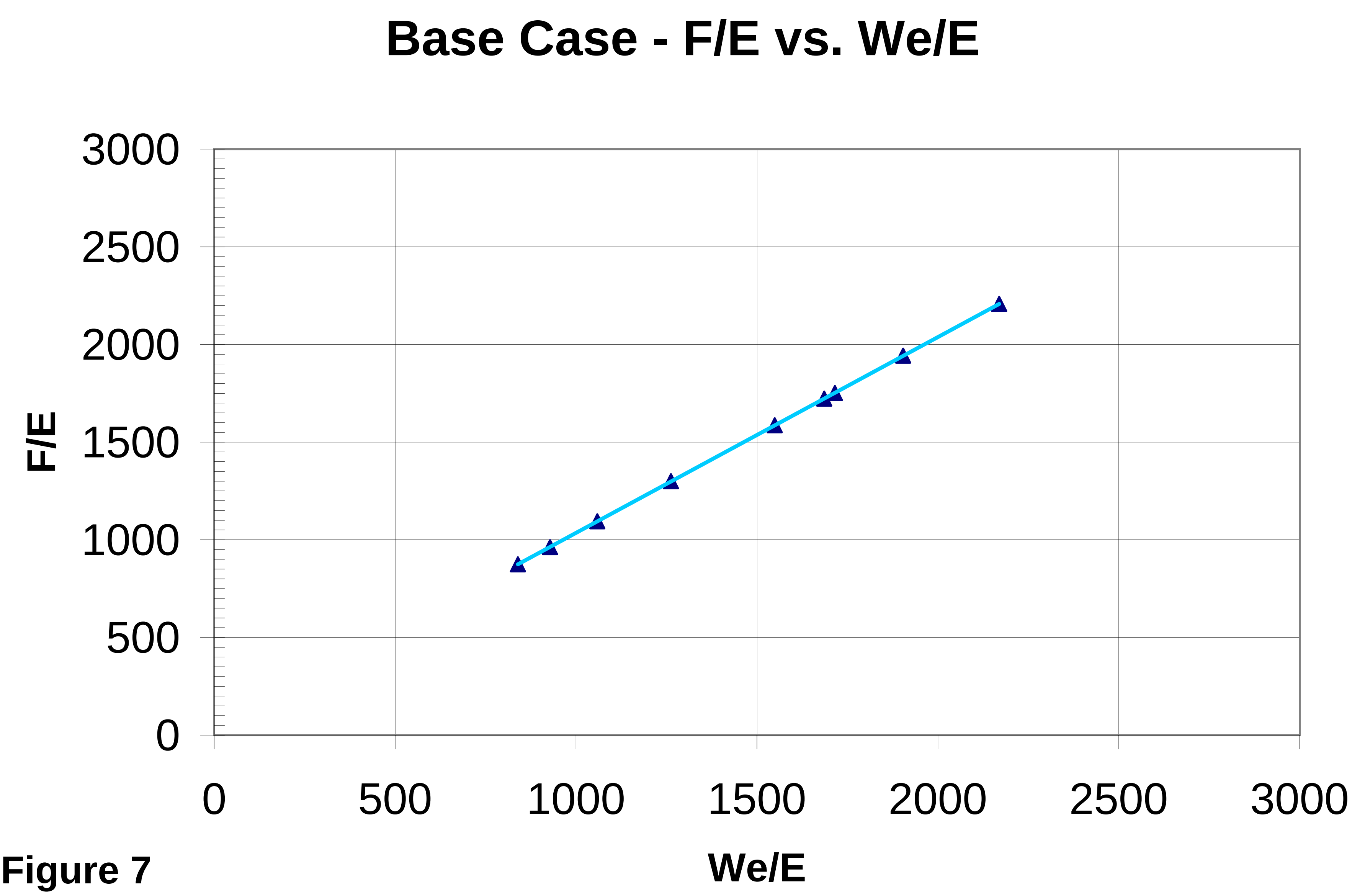

Base Case - F/E vs. We/E
3000
2500
2000
1500
1000
500
0
F/E
0
500
1000
1500
2000
2500
3000
We/E

Figure 7

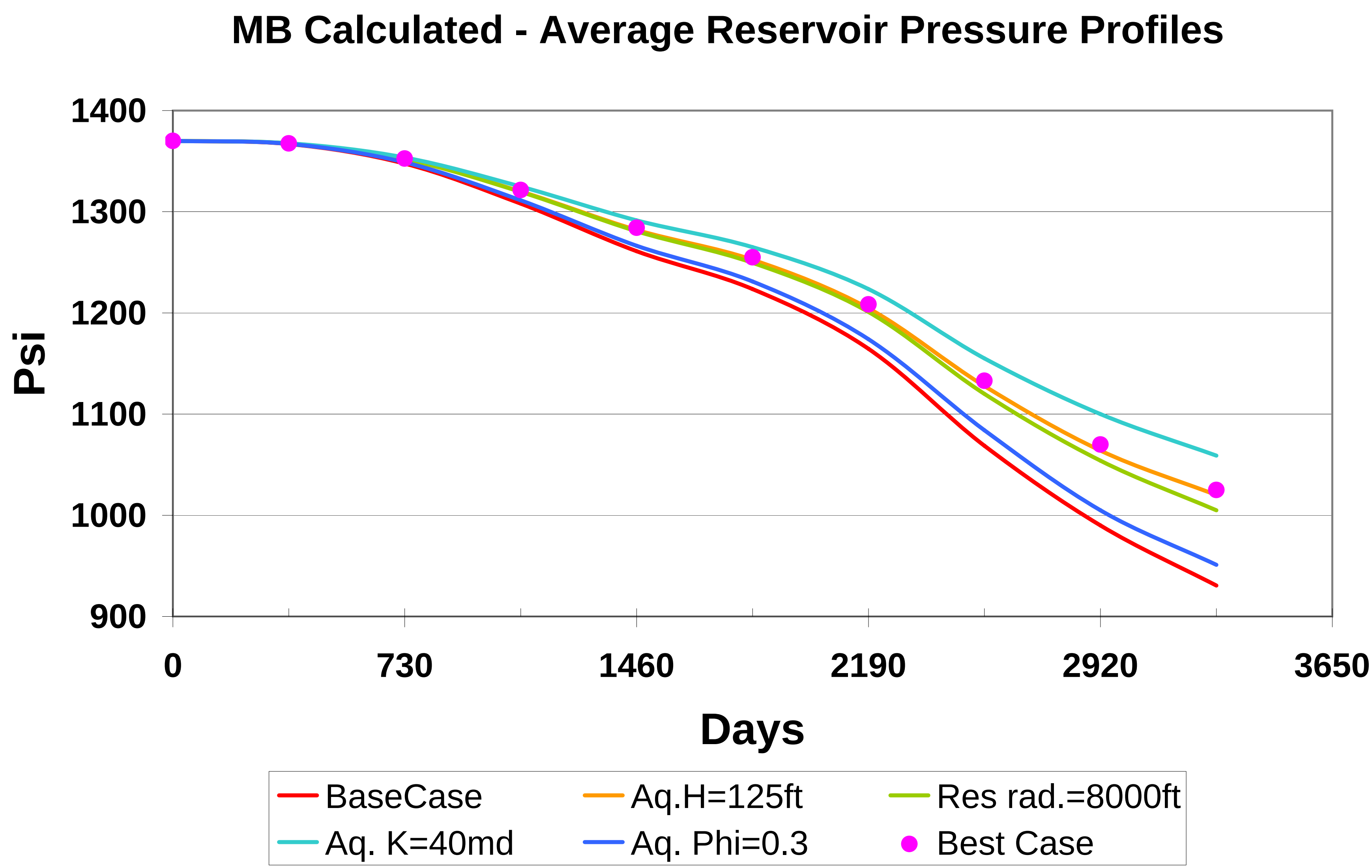

MB Calculated - Average Reservoir Pressure Profiles
1400
1300
1200
1100
1000
900
Psi
0
730
1460
2190
2920
3650
Days
BaseCase
Aq.H=125ft
Res rad.=8000ft
Aq. K=40md
Aq. Phi=0.3
Best Case

Figure 8

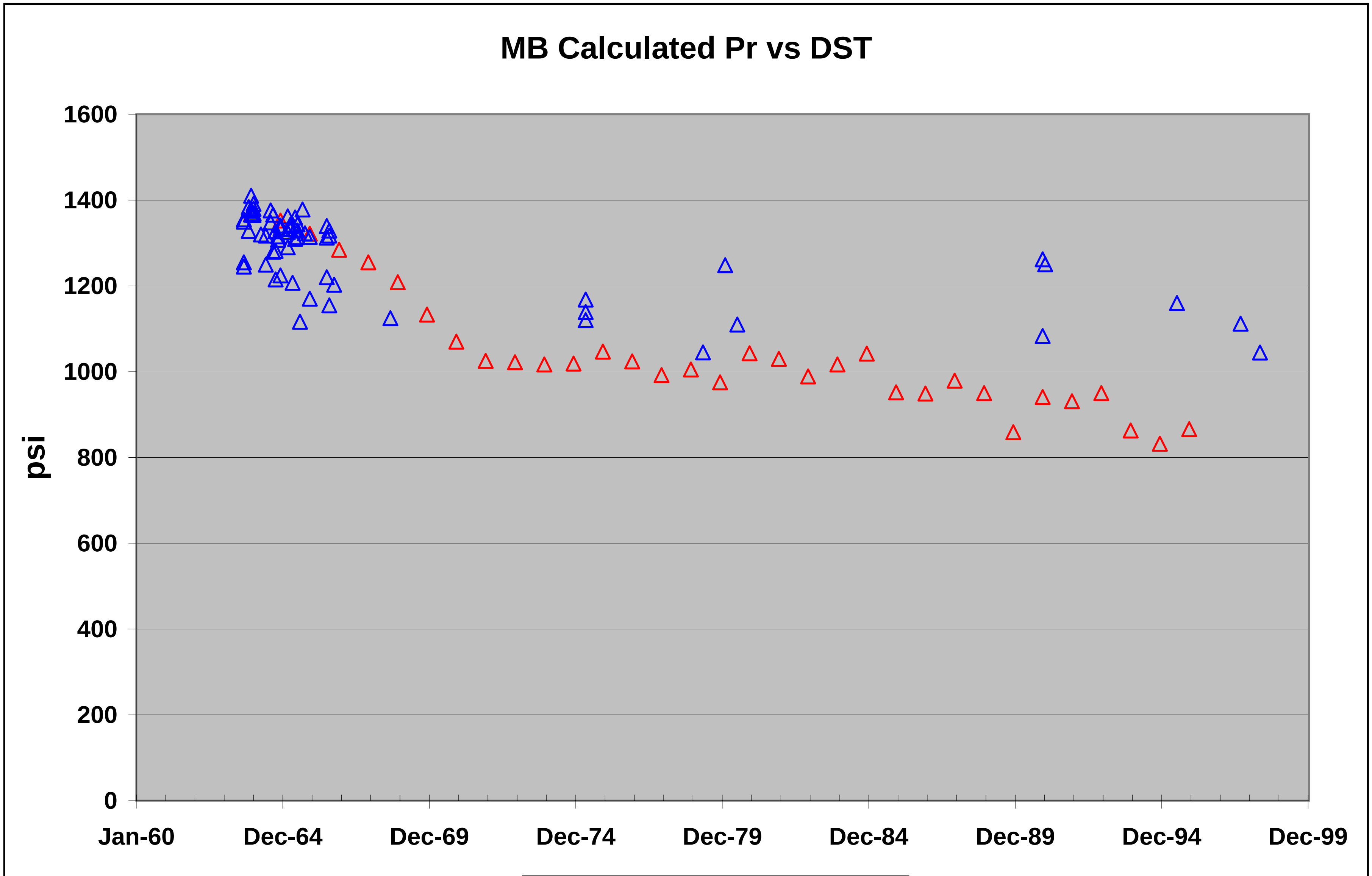

MB Calculated Pr vs DST
psi
1600
1400
1200
1000
800
600
400
200
0
Jan-60
Dec-64
Dec-69
Dec-74
Dec-79
Dec-84
Dec-89
Dec-94
Dec-99
MB - Pr
Avg Pr - DST

Figure 9

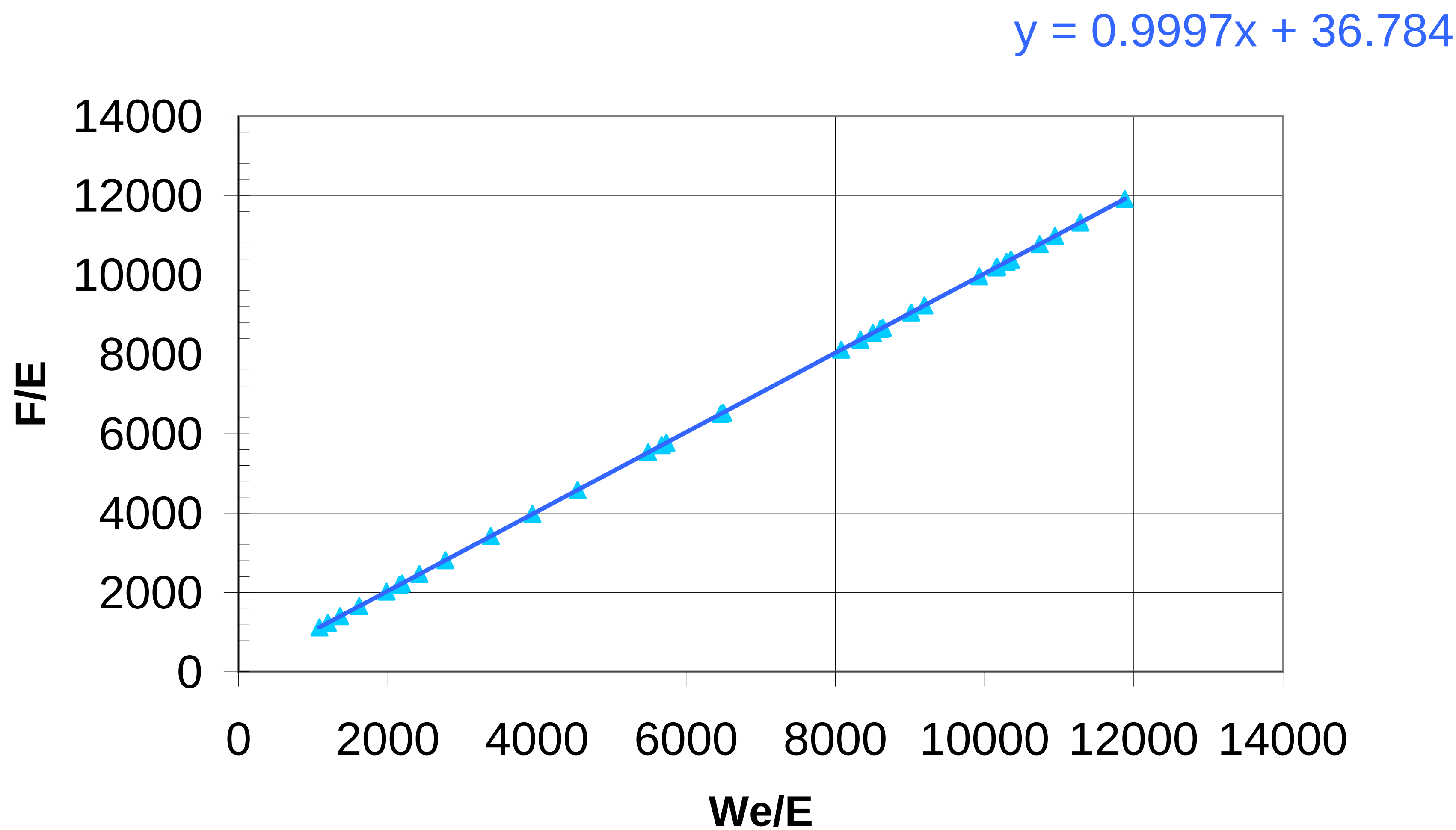


Figure 10

Material balance OOIP = 36.8 MMSTB