WEST VIRGINIA UNIVERSITY

PETROLEUM AND NATURAL GAS ENGINEERING

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FALL 99

PETROLEUM PROPERTY EVALUATION

PROJECT #2

DESIGN PROJECT

"PROPERTY EVALUATION"

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Executive Summary

Based on the data available our research team recommends that Bling Bling Inc. should invest in the Texas well. The Texas well is nearly 95 times more profitable at 15.5% interest rate, making the Texas well the investment choice.

Problem Statement

"Bling Bling Inc." has the opportunity to invest in two wells located in Lousianna and Texas. The current resources limit its management team to invest in one of the two wells. Given production data for the first four months of the two wells, the research team has been advised that the time value of money over the next three years is approximately 15.5%. The research team is to counsel management on what well is more profitable.

Background

This project represents an example of a property evaluation an engineer will execute in the field of Petroleum and Natural Gas Engineering. The process used to determine whether the Texas well or Louisiana well is most profitable is, type curve matching using Fetkovich type curve analysis. Fetkovich type curves are hyperbolic decline curves. This process uses a graphical technique that is mathematically based for predicting the future behavior of a well. Physical laws such as the flow of oil/gas through a reservoir are not essential. These Decline curves are very convenient to an engineer and are recommended for projects of this sort.

The hyperbolic decline was used for choosing between the Texas and Louisiana wells. The hyperbolic decline equation:

$$\mathbf{q=qi(1+bDit)^{-1/b}}$$

where:

q = production rate @ time t, (volume/time)
qi = production rate @ time t=0, (volume/time)
Di = Initial Nominal decline rate @ t=o, (1/time)
b = hyperbolic exponent
t = time

*Note:

- Any set of units may be used as long as (Dit) is unitless.
- (b) ranges between 0 and 1.
- When (b)=0 the hyperbolic decline equation turns to exponential decline equation.
- When (b)=1 the hyperbolic decline equation turns to harmonic decline equation.
- Hyperbolic decline rate changes with time.
- (Di) is the initial decline rate in hyperbolic decline.

To determine qi, Di, and b, one will need the following:

- Hyperbolic Decline Curve Analysis
- Trial and Error
- Find Di from a tangent
- Special tracing paper

(Refer to the Methodology section of this report for details of type curve matching using Fetkovich type curves)

Data

The research team has received four months of production data, and has been asked to use this data to provide a decline curve analysis and generate a monthly cash flow for the next three years for each well. Below is the data received:

Data for the well in Texas

Time Day	Rate (BOPD)
1	92800
2	81390
4	69980
6	58800
8	50100
10	41800
20	25000
30	15000
40	10500
50	8000
70	4800
100	2600
120	2000

Data for the well in Louisiana

Time (Day)	Rate (BOPD)
1	93000
2	81500
4	70000
6	53000
8	43000
10	38500
20	18000
30	9000
40	5000
50	2900
70	1100
100	370
120	200

Investment costs for the Texas well, and Louisiana well are $1,000,000 and $100,000 respectively.

Methodology

Using the four months of production data provided for each well, plotting this data on log-log tracing paper, and comparing it with an empirical type curve, the wells were determined to both be hyperbolic. The initial flowrate and the decline were also acquired. Below are the steps to use type curve matching.

	Price of oil ($/bbl)		
	Year 1	Year 2	Year 3
Texas	17	17.85	18.75
Louisiana	18.95	19.9	20.9

	Operation Costs ($/bbl)		
	Year 1	Year 2	Year 3
Texas	5.51	5.51	5.51
Louisiana	4.93	4.93	4.93

1. Place a sheet of tracing paper over the type curve.
2. Mark the axis and major lines.
3. Label the axis scale according to the data that is available to you.
4. Plot the data on the tracing paper as dots. (Do not connect the dots)
5. Place the tracing paper on the matching type curve log-log paper and make sure the axis lines of the tracing paper and the type curve paper are parallel. Move the tracing paper until the best matching type curve is obtained. The paper may only be

moved in the horizontal and vertical directions, absolutely no rotational movement. If necessary more weight should be given to the later data points.

6. Once a good match has been obtained, pick a match point. It can be anywhere on the paper, it does not have to be on the curve. (Usually an inter section of the major gridlines on the tracing paper is used)
7. Record the values from the tracing paper, (q, t) and the corresponding values lying beneath the point on the type curve grid (q_{Dd}, t_{Td}). Depending on where the data points match it falls in empirical region, or the analytical region. The empirical region is where the information is most desirable for this project.

Analyzing the Curve Found

The hyperbolic constant (b) can be read directly off the type curve in this region. The initial flowrate (q_i) is found by taking the match point production (q) and dividing by the match point dimensionless production (q_{Dd}). The initial decline rate (Di) is found by taking the match point dimensionless time (t_{Dd}) and dividing by the match point time (t).

Evaluating the Data

Using the initial flowrate, initial decline rate, and hyperbolic decline constant the flowrate for any time can now be calculated using the equation below.

$$q = q_i(1+Di*t)^{-(1/b)}$$

Using the initial flowrate, initial decline rate, hyperbolic decline constant and the flowrate for any time the cumulative production can be found by using the equation below.

$$Np = (q_i^{b}/(Di(1-b)))*[q_i^{1-b} - q^{1-b}] *f$$

*f = factor to cancel time units

Analyzing Data

An excel spread sheet has been created showing the expected production for both projects on a monthly basis. First the flowrate is found for the given month. The cumulative production can then be found. The cumulative production of any given month is then subtracted from that of the previous month to obtain the barrels of oil produced that month. The income can then be found by multiplying the amount of barrels produced by the expected price of oil. The expected operation costs of producing the oil is then subtracted to leave produce a net cash flow. The net cash flow is then subjected to a net present value profile.

Results

Texas Well:

Month	Net Present Value Profile 0.00%	5%	10%	15.50%	25%	50%	100%	300%	500%
	-1000000	-1000000	-1000000	-1000000	-1000000	-100000	-100000	-100000	-100000
	[illegible]	13803438.06	13746399.06	13684198.15	13578075.8	13306514.29	12794725.27	11088761.9	9784201.681
2	3430928.807	3402515.44	3374453.577	3343984.626	3292319.855	3161943.989	2923394.96	2195794.437	1709528.541
3	1555025.287	[illegible]	1516788.694	1496291.829	1461749.411	1375786.852	1223069.502	796172.9468	546933.3799
4	887330.8133	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Texas Well	
Time (Day)	Rate (BOPD)
0	100,000
1	92800
2	81390
4	69980
6	63900
8	50100
10	41800
20	25000
30	15000
40	10500
50	8000
70	4800
100	2600
120	2000

Match Point

qtd	q	Ttd	T
0.01	1000	1	10

qi	Di	b
100,000	0.1	0.5

Price of Oil	$17.00
Oil Increases	5%
Production Cost	$5.50 per barrel
Operation Cost	$1,000,000
Our Company Time Value of Money	15.50%

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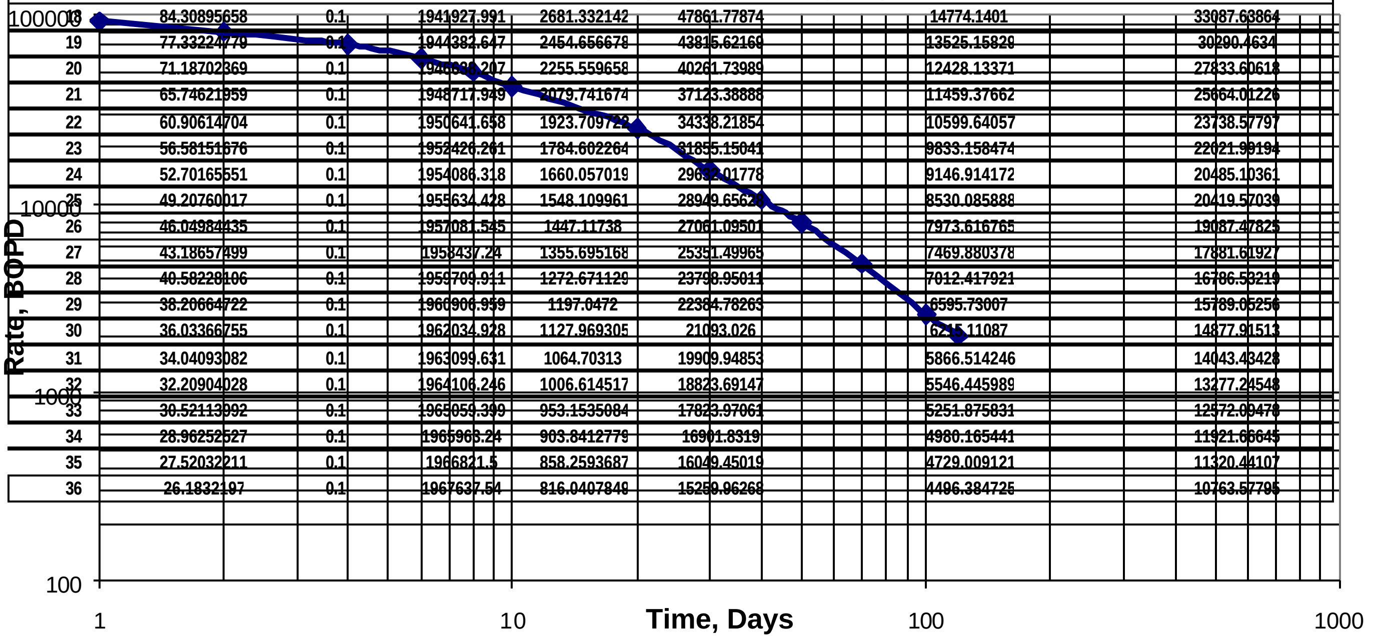
Month									
0	-1000000	-1000000	-1000000	-1000000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	573669.6886	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	401342.0351	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	296524.184	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	228026.1962	224265.02	220581.0733	216615.6719	209973.9277	193673.2654	165552.7189	93399.52997	56612.72261
5	180805.5125	177085.3618	173456.6866	169567.6814	163093.8009	147423.8785	121171.6819	59246.35035	31686.42849
6	146876.5768	143257.6217	139742.2709	135991.0226	129784.6966	114968.7847	90861.50052	38502.81336	18169.64701
7	121678.7894	118188.2424	114811.6637	111224.0898	105324.8821	91435.21943	69483.252	25517.89165	10625.29882
8	102453.0347	99101.08746	95872.01005	92455.99781	86873.25334	73908.55159	54004.25471	17188.76694	6315.146421
9	87450.2782	84238.18242	81156.64349	77910.8139	72638.62447	60562.2906	42550.26205	11737.37765	3804.977714
10	75518.1038	72442.4397	69504.00555	66422.29931	61447.27812	50206.90001	33917.98268	8108.694652	2319.3929

Monthly

Month	q	D	Np	delta Np	Cost	Operation Cost	Net Cash Flow
0	100000	0.1	0	0	0	0	0
1	[illegible]	0.1	1206349.206	1206349.206	20507936.51	6646984.127	13860952.38
2	[illegible]	0.1	[illegible]	[illegible]	[illegible]	[illegible]	3430928.807
3	[illegible]	0.1	1640287.77	135337.2747	2300733.67	[illegible]	1555025.287
4	[illegible]	0.1	1717514.124	77226.35451	1312848.027	[illegible]	887330.8133
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	7610.99027	129386.8346	[illegible]	87450.2782
10	[illegible]	[illegible]	[illegible]	6572.506858	111732.6166	[illegible]	78518.1038
11	176.5412047	0.1	1915966.387	5732.993377	97460.88741	31588.79351	65872.0939
12	155.9813222	0.1	1921011.058	5044.671897	85759.42225	27796.14215	57963.2801
13	138.814546	0.1	1925484.352	4473.293262	79848.28473	24647.84587	55200.43885
14	124.3332247	0.1	1929478.138	3993.786509	71289.08919	22005.76366	49283.32552
15	[illegible]	0.1	[illegible]	3587.457493	64036.11626	[illegible]	44269.22547
16	101.4239929	0.1	1936305.732	3240.136768	57836.44131	17853.15359	39983.28772
17	92.27421238	0.1	[illegible]	[illegible]	[illegible]	16204.50271	36291.02785
18	84.30895658	0.1	1941927.991	2681.332142	47861.77874	14774.1401	33087.63864
19	77.33224779	0.1	1944382.647	2454.656678	43815.62169	13525.15829	30290.4634
20	71.18702369	0.1	[illegible]	2255.559658	40261.73989	12428.13371	27833.60618
21	65.74621959	0.1	1948717.949	2079.741674	37123.38888	11459.37662	25664.01226
22	60.90614704	0.1	1950641.658	1923.709728	34338.21854	10599.64057	23738.57797
23	56.58151676	0.1	1952426.261	1784.602264	31855.15041	9833.158474	22021.99194
24	52.70165551	0.1	1954086.318	1660.057019	29632.01778	9146.914172	20485.10361
25	49.20760017	0.1	1955634.428	1548.109961	28949.65628	8530.085888	20419.57039
26	46.04984435	0.1	1957081.545	1447.11738	27061.09501	7973.616765	19087.47825
27	43.18657499	0.1	1958437.24	1355.695168	25351.49965	7469.880378	17881.61927
28	40.58228106	0.1	1959709.911	1272.671129	23798.95011	7012.417921	16786.53219
29	38.20664722	0.1	1960906.959	1197.0472	22384.78263	6595.73007	15789.05256
30	36.03366755	0.1	1962034.928	1127.969305	21093.026	6215.11087	14877.91513
31	34.04093082	0.1	1963099.631	1064.70313	19909.94853	5866.514246	14043.43428
32	32.20904028	0.1	1964106.246	1006.614517	18823.69147	5546.445989	13277.24548
33	30.52113992	0.1	1965059.399	953.1535084	17823.97061	5251.875831	12572.09478
34	28.96252527	0.1	1965963.24	903.8412779	16901.8319	4980.165441	11921.66645
35	27.52032211	0.1	1966821.5	858.2593687	16049.45019	4729.009121	11320.44107
36	26.1832197	0.1	1967637.54	816.0407848	15259.96268	4496.384725	10763.57795

O	U	R	P
0			

Texas Well Rate (BOPD) vs. Time (Days)



Louisiana Well:

Louisiana Well	
Time (Day)	Rate (BOPD)
1	93000
2	81500
4	70,000
6	53000
8	43000
10	38500
20	18000
30	9000
40	5000
50	2900
70	1100
100	370
120	200

Match Point

qtd	q	Ttd	T
0.1	10000	100	1000

qi	Di	b
100,000	0.1	0.2

Price of Oil	**$18.95**
Oil Increases	**5%**
Production Cost	**$5.50 per barrel**
Operation Cost	**$1,000,000**
Our Company Time Value of Money	**15.50%**

Monthly

Month	q	D	Np	delta Np	Income	Operation Cost	Net Cash Flow
0	100000	0.1	0	0	0	0	0
1	9301.859554	0.1	1063032.623	1063032.623	20144468.21	5240750.831	14903717.37
2	1871.333618	0.1	1198164.059	135131.4358	2560740.709	666197.9785	1894542.73
3	556.7709123	0.1	1230345.987	32181.92802	609847.536	158656.9052	451190.6309
4	210.0214266	0.1	1240990.081	10644.094	201705.5814	52475.38344	149230.1979
	O		U		R		P
0							
1	92.91657106	0.1	1245307.713	4317.632362	81819.13326	23790.15431	58028.97894
2	46.09665406	0.1	1247321.784	2014.071238	38166.64995	11097.53252	27069.11743
3	24.93005389	0.1	1248362.095	1040.31106	19713.89459	5732.113942	13981.78065
4	14.4221561	0.1	1248942.856	580.7604984	11005.41144	3199.990346	7805.421098
5	8.806583495	0.1	1249287.547	344.6914373	6531.902736	1899.249819	4632.652917
6	5.621260497	0.1	1249502.518	214.9710508	4073.701412	1184.49049	2889.210922
7	3.723343692	0.1	1249642.187	139.6682251	2646.712866	769.5719204	1877.140946
8	2.544815393	0.1	1249736.103	93.91597257	1779.70768	517.4770088	1262.230671
9	1.786793004	0.1	1249801.13	65.02729493	1232.267239	358.3003951	873.9668439
10	1.28422403	0.1	1249847.306	46.17582421	875.0318688	254.4287914	620.6030774
11	0.942100941	0.1	1249880.824	33.51846813	635.174971	184.6867594	450.4882116
12	0.703730179	0.1	1249905.63	24.80555202	470.0652108	136.6785916	333.3866192
13	0.534196224	0.1	1249924.304	18.67461206	371.5780934	102.8971124	268.680981
14	0.411387438	0.1	1249938.58	14.27546039	284.0459731	78.65778675	205.3881864
15	0.320948498	0.1	1249949.643	11.06332526	220.1325144	60.95892218	159.1735922
16	0.253349793	0.1	1249958.324	8.68077835	172.7257872	47.83108871	124.8946985
17	0.202136952	0.1	1249965.212	6.888271439	137.059381	37.95437563	99.10500533
18	0.162858218	0.1	1249970.734	5.522147645	109.8769328	30.42703353	79.44989925
19	0.132391828	0.1	1249975.203	4.468632495	88.91461507	24.62216505	64.29245002
20	0.108515274	0.1	1249978.85	3.647362541	72.57339617	20.0969676	52.47642856
21	0.089624125	0.1	1249981.851	3.000741557	59.70725512	16.53408598	43.17316914
22	0.07454522	0.1	1249984.338	2.486934452	49.48377826	13.70300883	35.78076943
23	0.062410537	0.1	1249986.413	2.075176884	41.29083204	11.43422463	29.85660741
24	0.052570742	0.1	1249988.156	1.742585757	34.6731001	9.601647521	25.07145258
25	0.04453512	0.1	1249989.628	1.471958821	30.68298162	8.110493102	22.57248852
26	0.037929285	0.1	1249990.878	1.250236182	26.06117321	6.888801362	19.17237185
27	0.032465063	0.1	1249991.945	1.067411145	22.25018533	5.881435411	16.36874992
28	0.027918779	0.1	1249992.861	0.915750158	19.08881204	5.045783369	14.04302867
29	0.024115472	0.1	1249993.65	0.789228035	16.45145839	4.348646474	12.10281192
30	0.020917272	0.1	1249994.334	0.683114887	14.23952983	3.76396303	10.4755668
31	0.018214786	0.1	1249994.927	0.593671099	12.37507406	3.271127756	9.103946304
32	0.015920649	0.1	1249995.445	0.517920067	10.7960438	2.853739571	7.942304232
33	0.013964659	0.1	1249995.899	0.453477445	9.452737337	2.498660721	6.954076616
34	0.012290071	0.1	1249996.297	0.398421803	8.305102484	2.195304135	6.109798349
35	0.010850769	0.1	1249996.648	0.351195932	7.3206792	1.935089585	5.385589616
36	0.009609073	0.1	1249996.959	0.310530979	6.473018251	1.711025693	4.761992559

	Net Present Value Profile										
Month	0.00%	5%	10%	15.50%	25%	50%	100%	300%	500%	700%	900%
0	-1000000	-1000000	-1000000	-1000000	-1000000	-100000	-100000	-100000	-100000	-100000	-100000
1	14903717.37	14841876.22	14780546.16	14713665.86	14599559.88	14307568.68	13757277.58	11922973.9	10520271.09	9412874.131	8516409.928
2	1894542.73	1878853.003	1863357.374	1846532.563	1818003.519	1746010.58	1614284.93	1212507.347	943993.6094	755717.8757	618626.1976
3	451190.6309	445597.4227	440096.2824	434149.1164	424126.633	399184.594	354873.6505	231009.603	158692.7356	113669.2536	84187.17311
4	149230.1979	146768.7217	144357.7877	141762.6577	137416.0132	126748.1553	108344.8543	61124.68907	37049.81244	23744.73327	15911.25809
	R	O	D	U	C	T	I	O	N		
0	-100000	-100000	-100000	-100000	-100000	-100000	-100000	-100000	-100000	-100000	-100000
1	58028.97894	57788.1948	57549.40061	57288.99608	56844.71407	55707.81979	53565.21133	46423.18316	40961.6322	36649.88144	33159.41654
2	27069.11743	26844.94351	26623.54286	26383.15093	25975.5296	24946.89863	23064.81012	17324.23516	13487.72633	10797.65349	8838.895489
3	13981.78065	13808.45478	13637.98196	13453.68742	13143.10437	12370.18468	10997.04914	7158.671693	4917.670866	3522.454726	2608.845369
4	7805.421098	7676.674644	7550.571786	7414.834628	7187.485265	6629.507559	5666.930846	3197.100482	1937.874449	1241.958026	832.2314873
5	4632.652917	4537.334102	4444.3591	4344.713846	4178.838145	3777.338706	3104.697074	1518.027708	811.8791474	465.5517775	282.2536197
6	2889.210922	2818.022412	2748.871904	2675.081052	2552.996339	2261.552355	1787.337677	757.389308	357.4153464	183.3771077	100.5891077
7	1877.140946	1823.292212	1771.20167	1715.8561	1624.848914	1410.57283	1071.91942	393.6649888	163.9166824	75.24720943	37.34483476
8	1262.230671	1220.934377	1181.151851	1139.066271	1070.286353	910.5600526	665.3373115	211.7671661	77.80317613	31.95655019	14.34941974
9	873.9668439	841.8655714	811.0690673	778.6306634	725.9410797	605.2517506	425.2418517	117.3018441	38.02645838	13.97474084	5.677439549
10	620.6030774	595.3274613	571.1795923	545.8543222	504.9699077	412.5971798	278.7358709	66.63674803	19.06062651	6.267442752	2.303739867
11	450.4882116	430.3478339	411.185758	391.1763071	359.0708598	287.5192946	186.7670512	38.69664272	9.766501075	2.873343362	0.955575256
12	333.3866192	317.1601062	301.7857116	285.8008785	260.3095211	204.2692345	127.5859612	22.91015402	5.101948389	1.34301204	0.40410254
13	268.680981	254.5432085	241.2033358	227.3937912	205.5057467	158.0385203	94.9138399	14.77089314	2.902399202	0.683590961	0.186098251
14	205.3881864	193.7734394	182.859581	171.6103275	153.8890302	115.9772275	66.97395906	9.033067965	1.566130709	0.330036894	0.081291058
15	159.1735922	149.5491691	140.5429785	131.3001615	116.8283862	86.28583635	47.91146201	5.600422894	0.8567535	0.161542089	0.035999817
16	124.8946985	116.8560468	109.364914	101.710205	89.79797052	64.99556638	34.70166427	3.515473235	0.474527295	0.080054606	0.016141178
17	99.10500533	92.34151054	86.06478271	79.67872903	69.8012603	49.51155324	25.41790679	2.231646325	0.265793961	0.040120428	0.00731895
18	79.44989925	73.72061257	68.42567873	63.06181156	54.81585381	38.10443667	18.80942148	1.431242147	0.150409475	0.02031379	0.003352806
19	64.29245002	59.40866039	54.91381482	50.38013773	43.4528199	29.60147853	14.05011753	0.926551853	0.085916019	0.010382101	0.001550376
20	52.47642856	48.28900457	44.45102551	40.59662477	34.74300806	23.19470915	10.58576248	0.60501203	0.049500634	0.005352013	0.000723108
21	43.17316914	39.56326375	36.26831005	32.97356237	28.00027094	18.31934001	8.039141963	0.398202201	0.028747014	0.002780958	0.00033995
22	35.78076943	32.65292241	29.80979171	26.97912737	22.73228734	14.5752765	6.150116431	0.264015479	0.016817476	0.001455653	0.000160995
23	29.85660741	27.13357622	24.66866228	[illegible]	[illegible]	[illegible]	4.73709412	0.176242303	0.009905672	0.000767143	7.67654E-05
24	25.07145258	22.69030199	20.5437875	18.42511832	15.28492362	9.412155413	3.671883946	0.118396587	0.005871584	0.000406858	3.68355E-05
25											9508E-05
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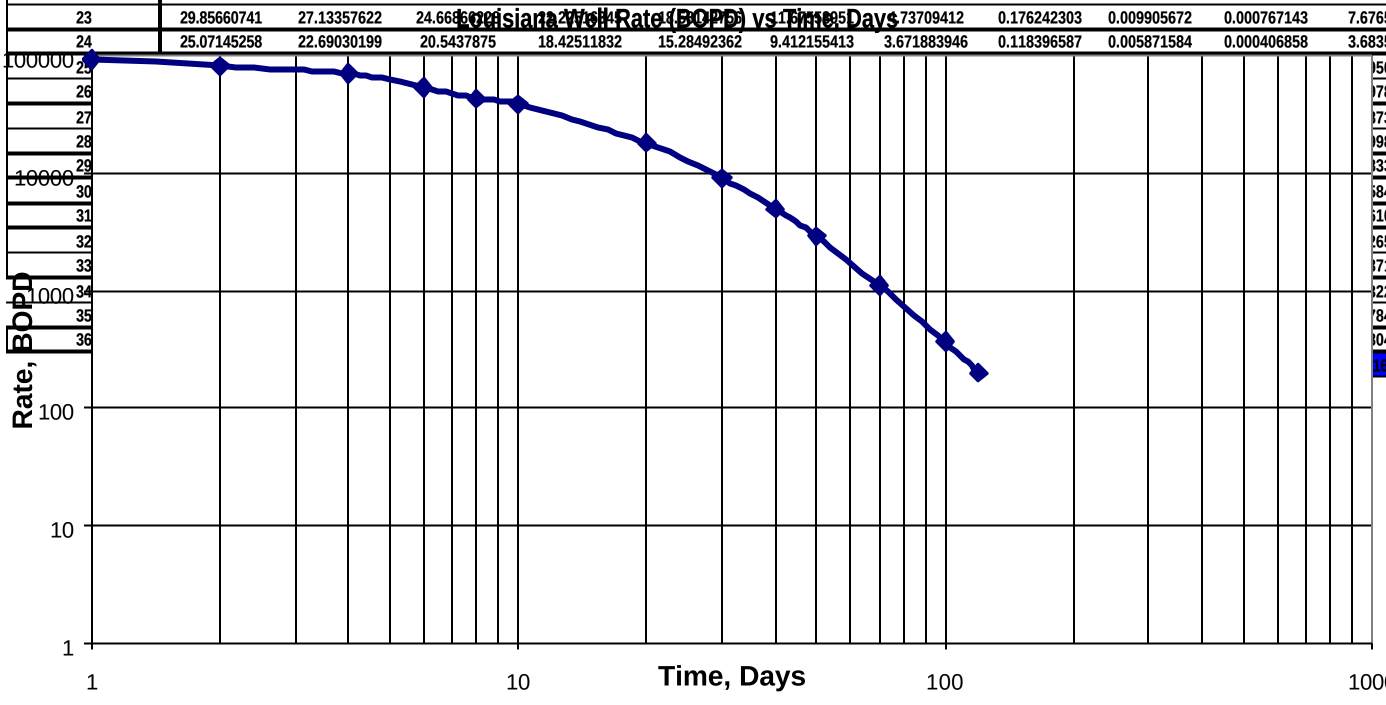

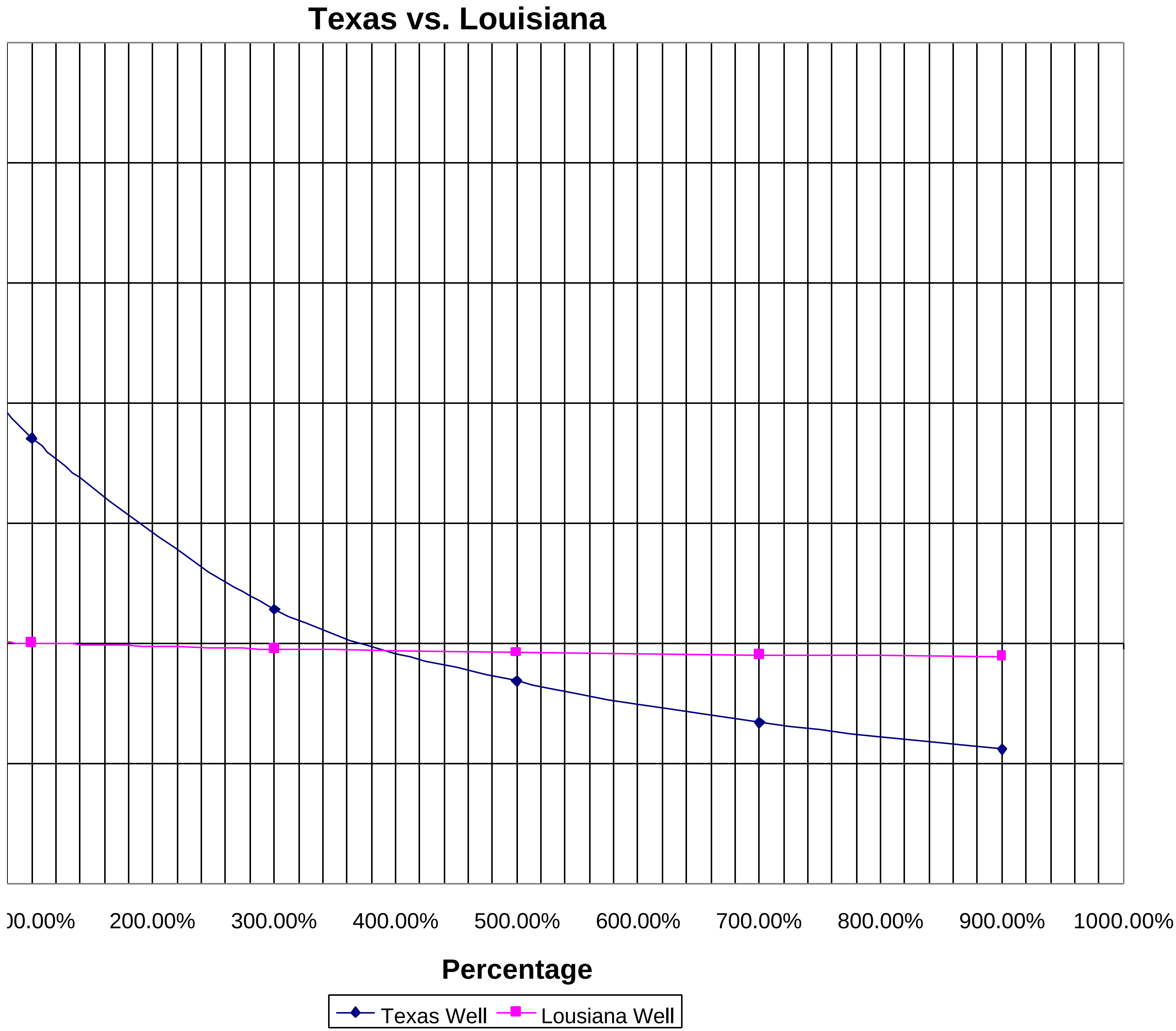
Texas vs. Louisiana
0.00%
200.00%
300.00%
400.00%
500.00%
600.00%
700.00%
800.00%
900.00%
1000.00%
Percentage
Texas Well
Lousiana Well

Conclusion

Based on the initial performance of the two wells the research team has determined that Bling Bling Inc. should invest in the Texas well. At 15.5% interest rate the Texas well will generate $ 1,670,000 while the Louisiana well will generate $17,500. Unless the interest rates where to skyrocket to nearly 400%, the Texas well is the clear choice for investment.

References

- Oil Property Evaluation, Robert S. Thompson and John D. Wright

- Petroleum and Natural Gas Engineering 241 Oil Property Evaluation Notes, West Virginia University, 1999

Appendix A

Appendix B