SWN: SHALE GAS GROWTH[1]

1. INTRODUCTION

Claudia Gomez has recently joined the corporate finance department of an independent gas development company, Southwestern Energy Company ("SWN"), which has developed substantial shale gas reserves in Arkansas and Appalachia. SWN claims to be one of the lowest cost developers of natural gas reserves in the U.S.[2] Her first assignment is to provide support for Juan Lopez, SWN CEO, who believes that the required "SEC" disclosure of the present value of proven reserves discounted at 10%, and with constant prices way undervalues the proven reserves.

Over the past three years proven developed reserves had increased, although reserves and present values declined significantly in 2015, when average natural gas prices reached a record low due to surplus gas production from SWN and other shale gas producers. **Table**

[1] © Dean A. Paxson, 2016. Parts of this case are from SWN 2015 10K, but the characters are fictitious. This case is not intended as an illustration of either good or bad business practices, and mixes hypothetical and actual data and names.

[2] See Investors Presentation Nov 2016.

1 shows the disclosed proven reserves, forecast future cash flows, production costs, future development costs, and other items.

Table 1

SWN PROVEN GAS RESERVES MMMcf Gas Only				
	2016	2015	2014	2013
PD				
BEGIN		5,675	4,237	3,196
END		5,474	5,675	4,237
PUD				
BEGIN		4,134	2,737	821
END		443	4,134	2,737
AVERAGE PRICE ASSUME		2.59	4.35	3.67
FUTURE CASH FLOWS $000000				
INFLOWS		11,887	41,812	22,624
COSTS		-7,376	-16,477	-8,896
DEVELOP COSTS		-792	-5,750	-3,626
INCOME TAX			-4,743	-3,223
NET CASH FLOWS		3,719	14,842	6,879
10% DISCOUNT		-1,302	-7,299	-3,143
SEC NET CASH FLOWS		2,417	7,543	3,736
ANALYSIS OF SEC STANDARDIZED MEASURE $000000				
SEC BEGIN		7,543	3,736	2,051
PRODUCTION		-1,082	-2,084	-1,774
CHANGES IN PRICES		-8,075	1,192	1,853
E,D & OA		162	1,049	1,454
ACQUIRE		28	1,897	5
SALE		-244		
REVISIONS		-1,385	622	349
DISCOUNT ACCRETION		946	513	232
CHANGE IN TAXES		1,915	-522	-1,120
CHANGE DEVELOP COSTS		2,882	925	27
CHANGE TIMING		-273	215	659
SEC END		2,417	7,543	3,736
SEC END CROSS CHECK		2,417	7,543	3,736

SWN has stated that "pre-tax PV-10 value of the estimated cash flows related to our estimated proven reserves is a useful supplement disclosure…we understand securities analysts use pre-tax PV-10 as one measure of the value of a company's current proven reserves and to compare relative values among peer companies without regard to income taxes". Juan believes that in addition using a 10% discount rate, historical average gas prices, ignoring the improvements over time in production and reserve development

costs, and indeed ignoring unproven reserves very substantially undervalues the SWN exploration, development and production portfolio.

Nevertheless, SWN values the PV methodology, as their rule for success appears to be invest when PV(10%)>1.3 Investment Cost. Although Lopez is not a big supporter of real option methodology, he wondered whether this now somewhat dated methodology might be useful in valuing proven undeveloped reserves (PUD) and unproven reserves (UN). Natural gas prices have been very volatile in the US over the last few years, and there seemed to be times when developing reserves was hardly profitable at current gas prices. Is this volatility increasing or decreasing over time? See **Figure 1** compared to **Figure 2**.

Figure 1

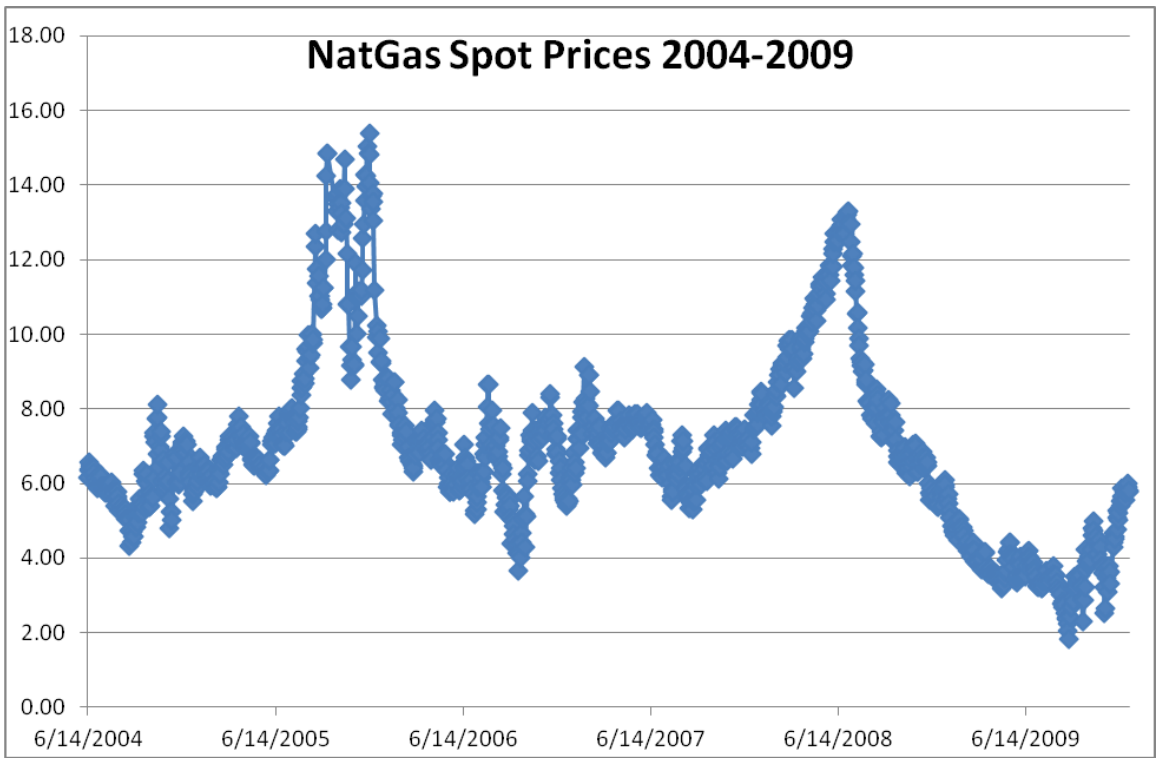
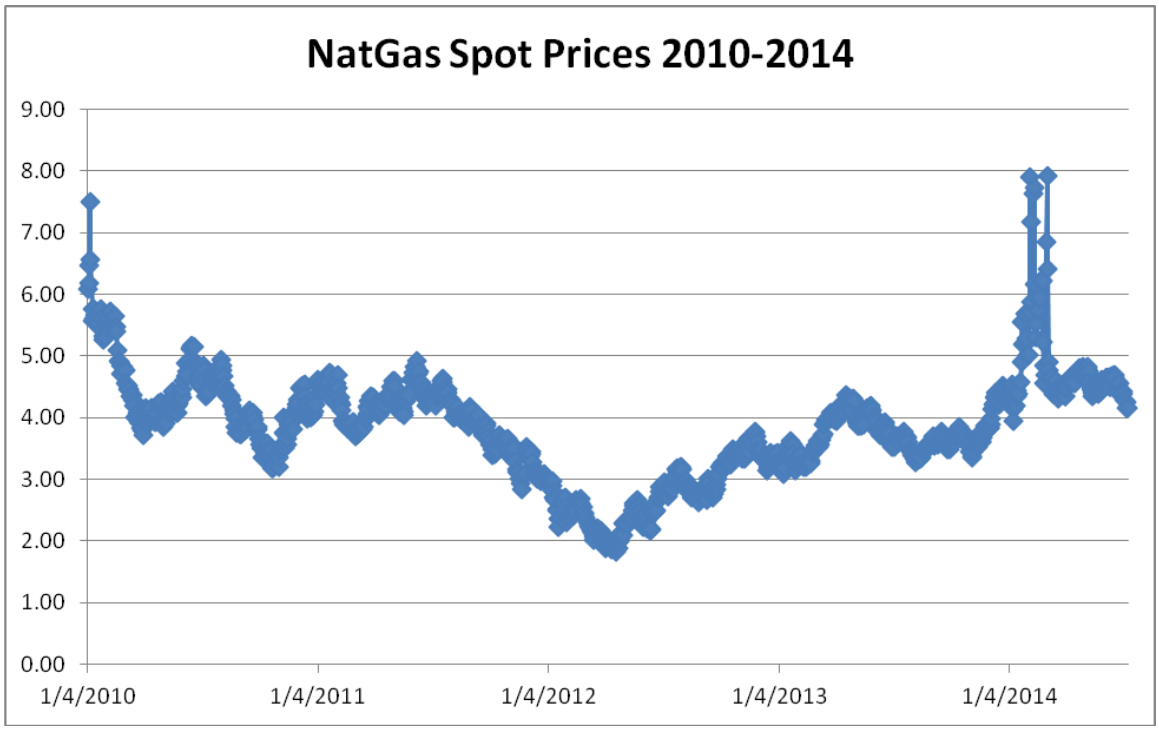


Figure 2



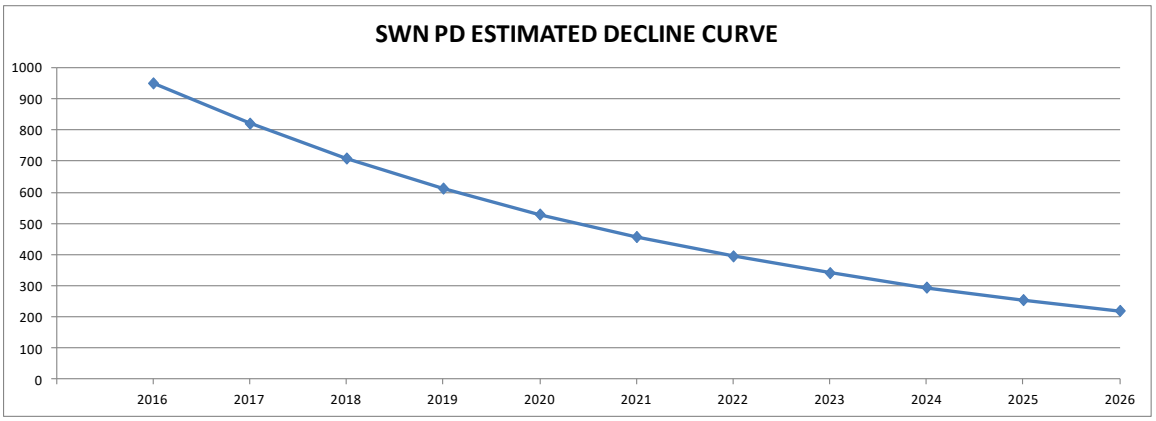
Claudia wonders whether long-term volatility best approximated by daily spot volatility, due to seasonality. Given the low risk of developing reserves for SWN, Lopez thinks that Claudia will be occupied sufficiently working out the model analysis and appropriate parameter values so she will produce little to surprise him over the next year "out of harm's way". The SWN people want to get on with their more important work continuing to develop reserves and sell gas in a difficult market. So while Claudia might come up with a higher value of the PUD reserves than the SEC methodology, little else will change. However, Claudia had taken an introductory course in real options, where it was argued that "not only is the NPV rule wrong, but substantially wrong, in the face of uncertainty".

2. SWN RESERVE ANALYSIS

Before trying to readjust the SEC standardized measure of reserve present value, it is first necessary to estimate the production decline curve, on which the pre-tax PV 10% of $2.4 billion is based. An external estimate shown in **Table 2** is only approximate, assumes

production ends after year twelve, production costs are $.83/MCF +$80, and production next year of 950 MMCF. If production declines at a hyperbolic rate of -.78 per annum, the gas price is constant at $1.75, the total BCF almost equals the SEC disclosure, and the 10% PV is $2.4 billion. **Figure 3** shows the estimated decline curve.

Figure 3



In **Table 3**, a similar decline curve is projected for the PUD but starting at a slightly higher gas price of $4, and with production next year set at arbitrary figure of 20% of disclosed SEC PUD reserves. When discounted at 10% the PUD production cash flow has a present value of $ 275 million, or slightly more than the PV of the disclosed investment cost of $ 235 million. The 10% PV of PD and PUD is close to the pre-tax 10% PV figure reported by SWN. Of course, Claudia would have more accurate figures than these estimates.

Substituting these 10% PV estimates for the accounting book value of proven reserves in the December 2015 SWN balance sheet, adding the book value of other assets and subtracting the real liabilities (ignoring deferred taxes) results in net assets per share of some $5.17, as shown in **Table 4**. Then it is assumed that the gathering system assets would be worth ten times operating profits ($ 306 million for 2015), the unproven properties shown in the 10K of $ 3727 million are assumed to be worth slightly more than the book value[3], and the PUD ROV is from **Table 5**. So the initial net "appraised" value per share is $ 9.87 as shown in **Table 4**.

[3] An alternative estimate is shown in Table 6.

Table 4

SWN 12/2015	ASSETS	LIAB	
CURRENT	393	707	
UNPROVEN	3727	4728	LTD
PD PV	2376	393	OL
PUD PV	40		
OTHER ASSETS (GATHERING)	1,313	2,021	NA
TOTAL PV BASIS	7,849		
SHARES	391	**$5.17**	
ALTERNATIVE VALUES		EXCESS PER SHARE	
GATHERING	3060	$4.47	
PUD ROV	112	$0.18	
UNPROVEN ROV	3744	$0.04	
TOTAL ROV		**$9.87**	
REFERENCE GAS PRICE		1.75	

3. THE SWN REAL OPTION

Claudia thinks a primary real option at SWN is the option to defer the investment decision, even if there are standard holding costs such as leasing or work requirements. Claudia is aware of several real option deferral models applied to petroleum projects, such as Tourinho (1979) and Bjerksund and Ekern (1990)[4]. Tourinho seemed the easiest model to comprehend (perhaps even Lopez could grasp the simple maths). Claudia believes if the Tourinho model as amended in Adkins and Paxson (2013) did not justify the project, greater model sophistication would be a practical waste of time. Tourinho (amended) states that the value of being able to perpetually defer an investment decision with an underlying "fundamental value" of V, when the risk less interest rate =r, the convenience yield=δ, annualized lease holding costs=η and the volatility of the project=σ, is:

$$F(V) = AV^{\beta_1} \qquad (1)$$

[4] See Adkins, R. and D. Paxson (2013), "The Tourinho Model: Neglected Nugget or a Receding Relic", European Journal of Finance, 19, 604-624; Bjerksund, P. and S. Ekern (1990),"Managing Investment Opportunities under Price Uncertainty: From 'Last Chance' to "Wait and See' Strategies", Financial Management, 19 (3), 65-83. Note Tourinho, O.A. (1979), "The Valuation of Reserves of Natural Resources: An Option Pricing Approach", Ph.D. Dissertation, University of California, Berkeley, assumed the real option holder would be required to pay an annual holding cost to maintain the concession during the deferral period.

where $\beta_1 = \frac{1}{2} - \frac{(r-\delta-\eta)}{\sigma^2} + \left\{\left[\frac{(r-\delta-\eta)}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}\right\}^{\frac{1}{2}} > 1$ (2)

$$V^* = \frac{\beta_1}{\beta_1 - 1} K \quad (3)$$

$$A = \frac{V^* - K}{(V^*)^{\beta_1}} \quad (4)$$

Initially Claudia inputs a riskless interest rate of 10%, a long-term convenience yield of 10% which is at least in "the right direction" with the current backwardation (long-term futures prices less nearby futures), a lease holding cost of 0% and a volatility of 50%. As illustrated in **Table 5**, when V=275, K=235, the real option value ROV= 112 and V*=683, which is the value of the project which would justify commencing the investment.

Table 5

	A	B	C
1		**PERPETUAL AMERICAN CALL**	
2	INPUT		
3	Holding Cost	0	
4	V	275	PUD!$B$15
5	K	235	PUD!$B$14
6	σ	0.50	Template Numbers
7	r	0.10	Template Numbers
8	δ_v	0.10	Template Numbers
9	OUTPUT		
10	ROV	**112.06**	IF(B4<B13,B14*(B4^B15),B11)
11	V-K	40.23	B4-B5
12	F'(V)	0.62	IF(B4<B13,B14*B15*(B4^(B15-1)),1)
13	V*	682.88	(B15/(B15-1))*B5
14	A	0.02	(B13-B5)/(B13^B15)
15	β1	1.52	0.5-(B7-B8-B3)/(B6^2)+SQRT(((B7-B8-B3)/(B6^2)-0.5)^2 + 2*B7/(B6^2))
16			
17	ODE	0.00	0.5*(B6^2)*(B4^2)*B18+(B7-B8-B3)*B4*B12-B7*B10
18	F''(V)	0.00	IF(B4<B13,B14*B15*(B15-1)*(B4^(B15-2)),0)
19	F'(V*)	1.00	B14*B15*(B13^(B15-1))
20	F(V*)	447.88	IF(B4<B13,B14*(B13^B15),B11)
21	V*-K	447.88	B13-B5
22	ROV -NPV	71.83	

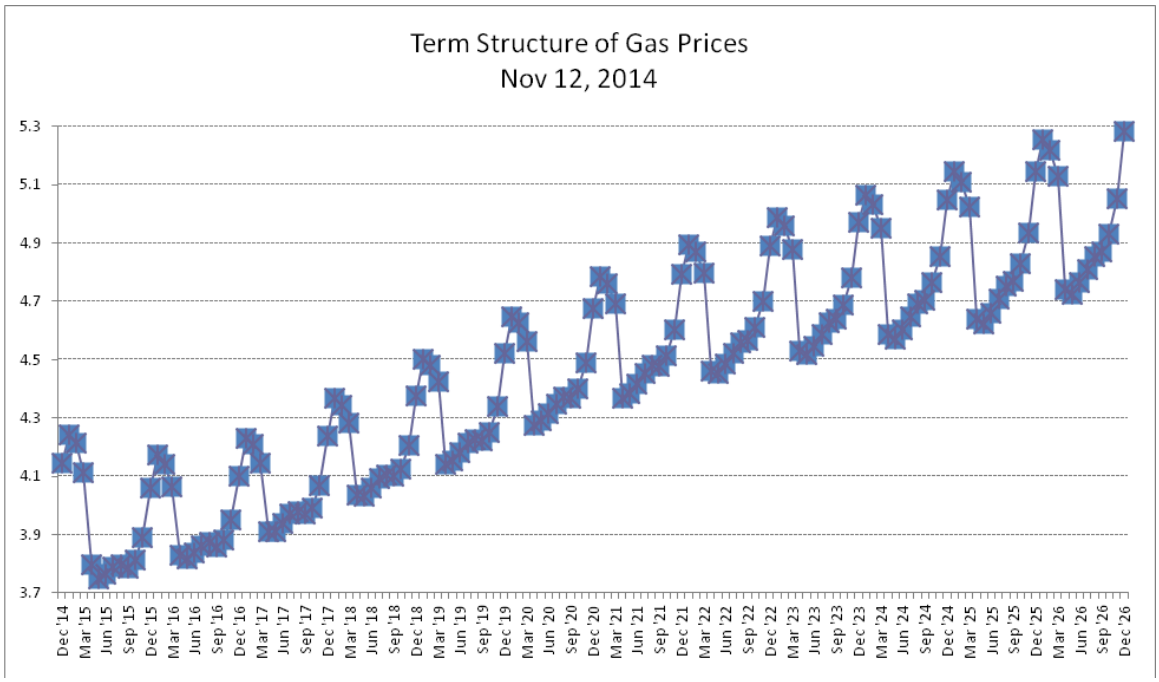
Claudia believes there are two major implications of her initial work. That indeed PUD are worth more than the PV figure, but the development of these reserves should be delayed until either more reserves are projected for the same investment cost, or natural

gas prices increase. She believes the 10% discount rate is not realistic in today's low interest rate environment, and that the arbitrary 50% volatility is much too high. The convenience yield is also a problem, with an easy calculation for specific natural gas future prices:

$$\delta_V = r - LN(\frac{F_t}{F_{t-1}}) \qquad (5)$$

where F_t is the futures price for year t, and F_{t-1} is the futures price for the previous year. One problem is that the convenience yield is uncertain and complicated by seasonality as shown in Figure 4, and another is that the convenience yield refers to different time periods in the future.

Figure 4



CASE QUESTIONS

1. What is the volatility of natural gas prices and interest rate that Claudia should use?
2. What should she provide Lopez as the best estimate of the ROV of PUD & UN updated from the recent SWN 10K ?
3. How sensitive are the real option values to changes in Claudia's assumptions?

4. What is SWN really worth, compared to the 15 March 2017 market price, using the updated account and reserve figures from SWN 10K ending Dec 2016?

Table 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**SWN PROVEN DEVELOPED RESERVES**													
2	TIME	Dec-15	1	2	3	4	5	6	7	8	9	10	11	12
3	HYPERBOLIC	-0.78												
4	GAS PRICE	1.75												
5	LOC	0.83												
6	LOC Fixed	80.00												
7	DISCOUNT	0.10												
8	YEAR		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
9	PRODUCTION		950	821	709	612	529	457	395	341	295	254	220	190
10	REVENUE	10072.14	1,658	1,432	1,237	1,069	923	797	689	595	514	444	384	331
11	COSTS	5750.76	869	761	668	588	519	459	408	363	324	291	262	238
12	FCF	4321.38	789	671	569	480	404	338	281	232	189	153	121	94
13	COSTS		$B$6+$B$5*C9											
14	INVESTMENT	$557												
15	PV	$2,933	NPV(B7,C12:N12)											
16	NPV	**$2,376**	$2,377											
17	SEC	5,772												
18	TOTAL BCF	5,772	0											
19	SOLVER: C18=0, CHANGE B3													
20	HYPERBOLIC SINH		Returns the hyperbolic sine of a number.											

Table 3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**SWN PROVEN UNDEVELOPED RESERVES**													
2	TIME		1	2	3	4	5	6	7	8	9	10	11	12
3	HYPERBOLIC	-0.75												
4	GAS PRICE	4.00	PD!$B$4+0.3											
5	LOC	0.87												
6	LOC Fixed	100.00												
7	DISCOUNT	0.10												
8	YEAR		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
9	PRODUCTION		89	72	59	48	40	32	27	22	18	15	12	10
10	REVENUE	1772	354	290	237	194	159	130	106	87	71	58	47	39
11	COSTS	1583	177	163	151	142	134	128	123	119	115	113	110	108
12	FCF	189	178	127	86	52	24	2	-17	-32	-44	-54	-63	-70
13	PRODUCTION		0.2*B17											
14	INVESTMENT	$235												
15	PV	$275												
16	NPV	**$40**	$40											
17	SEC	443												
18	TOTAL BCF	443	0											
19	SOLVER: C18=0, CHANGE B3													
20														
21	PV PD	$2,376												
22	NPV PUD	$40												
23	Total NPV Model	$2,416												
24	Total NPV SWN	$2,417												
25			PER BCF											
26	INVESTMENT	$235	$0.53											
27	PV	$275	$0.62											
28	GAS PRICE		4.00											

Table 6

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**SWN UNPROVEN RESERVES**															
2	TIME		1	2	3	4	5	6	7	8	9	10	11	12		
3	HYPERBOLIC	-0.75														
4	GAS PRICE	3.44														
5	LOC	0.95														
6	LOC Fixed	180.00														
7	DISCOUNT	0.10														
8	YEAR		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
9	PRODUCTION		0	0	994	813	665	544	445	364	298	243	199	163	133	109
10	REVENUE		0	0	3,414	2,792	2,284	1,868	1,528	1,250	1,022	836	684	559	458	374
11	COSTS		0	0	1,124	952	812	697	603	526	463	411	369	335	307	284
12	FCF		0	0	2,290	1,840	1,472	1,171	925	724	560	425	315	225	151	91
13	PRODUCTION				0.2*B17											
14	INVESTMENT	$2,288		1,318	1,318											
15	PV	$6,016			Assume production does not begin for two years.											
16	NPV	**$3,728**														
17	SEC	4,969														
18	TOTAL BCF	4,969														
19	SOLVER: C18=0, CHANGE B3															
20																
21	NET BOOK VALUE	3,727	NPV		If book value =NPV, and there are about possible reserves are worth about											
22	SUPPOSE P VALUE	6,016	1.21		$ .75 per MCF, then total BCF=B27.											
23	PV INVESTMENT	2,288														
24	NPV	3,728			Then NPV equals book value at $3.44 per MCF, and assumed higher LOC.											
25			PER BCF													
26	INVESTMENT	235	0.53		Assume about the same K is required to develop these reserves as for PUD.											
27	UNPROVEN ESTIMATED BCF	4,969	0.75													
28	INVESTMENT	2,636			Then total K is about B28, spread over two years, for a PV of B14.											