Case Study

Deer Meadows Oil Field[1]

Your company is considering bidding on an oil field. The field was developed a number of years ago, and the seller's capital investments in equipment are fully depreciated. Nonetheless, the field is expected to remain at least marginally productive for about 40 years. A significant aspect of the appeal of the field to your company, however, is that there appear to be substantial reserves that are not yet developed. Your responsibility is to prepare an analysis that the company board of directors can use as a basis for determining how much to bid for the field.

Projecting Reserves and Production

As the primary basis for your work, you have been provided with engineering estimates of the potential production of the field for both the developed reserves and the prospective reserves. Consistent with industry practice, the engineers classify reserves as proved, probable, or possible. Developed reserves are largely proved and the estimates of future yields are fairly certain. Undeveloped reserves are mainly probable and possible and are substantially less certain. Generally, proved reserves are almost certain to be realized, probable reserves are more likely than not to be realized, and possible reserves are less likely than not to be realized.

To estimate expected reserves and uncertainty of production, a two-step process commonly is used. First, Monte Carlo simulation is used to generate a distribution of possible production volumes that are conditional on successful development of a tract. Uncertainty information used in the simulation comes from data on the variation of realized yields from tracts that are geologically similar to the tract being evaluated. The simulation results are used to classify reserves as proved, probable, or possible.

Second, the statistically-generated yield forecasts are "risked." Risking involves application of judgment to the projections, where the judgment is intended to adjust for the potential that a tract will not be successfully developed. Thus, by weighting the statistically-generated projections by a judgment factor that reflects the likelihood of successful development, an estimate of (statistically) expected yield is developed. For tracts that already are developed, the second step of the estimation process is not required.

Exhibit 1 sets out the engineering estimates of "risked" reserves and production for the 60-year projected life of the Deer Meadows Oil Field.[2] The exhibit contains information on projected production volumes for both proved and total reserves. Actual production would include a mixture of various grades of crude oil and natural gas. For convenience, the figures in the exhibit are stated in terms of a standardized unit - barrel of oil equivalents per day (BOEPD).

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[1] Data and company name have been disguised to preserve confidentiality.
[2] All exhibits are available as downloadable Excel files.

Projecting Prices

Price per BOE is estimated annually by forecasting the price of each component product and weighting the components based on their contributions to the BOE. All prices are projected in real terms based on a forecast of expected prices of petroleum products. Real prices fluctuate over time as the composition of products changes and in response to projected changes in supplies and demands for various petroleum products.

Exhibit 2 shows the price per BOE projections for the proved and total reserves of the field. Prices in the exhibit reflect the changing mix of products expected to be recovered from the field. In general, proved reserve prices are lower because they are drawn primarily from the existing tracts, where the higher-valued products already have been extracted. For both proved and not-proved reserves, BOE prices tend to decline over time as the mix of products changes. The total reserve prices in the exhibit are computed as weighted averages using the revenue estimates in Exhibit 4.

The price projections in Exhibit 2 represent a Base Case forecast. They are regarded appropriately as the prices that (in a statistical sense) are expected to be realized. Actual prices, however, are subject to considerable uncertainty. To gauge the uncertainty, the engineering staff has generated estimates of Low Case and High Case price differentials. The differentials, expressed in percentage terms in Exhibit 3, are generated based on a forecast for a hypothetical barrel of constant-quality crude oil over time. The percentage differences represent the 25th and 75th percentiles of price dispersions relative to the projected Base Case price for the hypothetical barrel. Because prices of different petroleum products are highly correlated with each other, the percentage differentials in Exhibit 3 can be applied reasonably to the Base Case price projections in Exhibit 2, as a means of assessing the effect of price uncertainty on revenue. However, the High and Low Case price differentials are not projected as long-term price paths. In fact, oil prices can fluctuate dramatically from one year to the next. In other words, just because the price is high in one year does not mean it is expected to by high in the next.

The industry recognizes that it is important to distinguish between price uncertainty and volume uncertainty, as, to some degree, it is possible to adjust yields in response to price changes and differences between current and expected future prices. For example, if the price is very low in one year, it could make sense for the field operator to reduce or even discontinue production. If price is very high, and is not expected to remain high, it could make sense to accelerate production somewhat.

Revenue and Expense Projections

Exhibit 4 contains revenue projections for the field. These projections are derived by multiplying the expected volumes in Exhibit 1 by the expected BOE real prices in Exhibit 2. The field will incur annual operating expenses, including direct operating expenses as well as SG&A expenses. Projected operating expenses are reported in real terms in Exhibit 5. The figures in this exhibit do not include expenses related to interest payments, taxes, depreciation of capital expenditures, or depletion of reserves.

To develop the additional tracts according to the plan reflected in the volume projections, the company would need to make significant capital expenditures during the first 15 years after the acquisition. Projected expenditures are as shown in Exhibit 6. The expenditures are fully depreciable. Typically, a capital investment can be expensed evenly over a seven-year period, including the year in which the expenditure is made.

The bid price for the field would be for acquisition of the mineral rights. As such, it can be expensed over the life of the field, in approximate proportion to the rate at which the field is depleted. The volume information in Exhibit 1 can be used to project annual depletion (non-cash) expenses related to the acquisition price.

The company does not anticipate any material change in net working capital requirements associated with acquiring and developing the field.

The company anticipates that that the proved-reserve component of expected cash flows will be sufficient to support financing about 30 percent of the acquisition price with high-grade corporate debt. To maintain a consistent capital structure over time, the objective would be to adjust the amount of debt outstanding each year in proportion to anticipated depletion of the field.

The effective corporate combined state and federal income tax rate is 37 percent. Regardless of whether the field generates positive or negative net income in any year, the company has enough income from other activities to fully realize the benefits of tax deductibility of interest expense related to the field and to offset any negative net income from the field.

The Assignment

You recognize that the company board is a diverse group and that different board members are likely to emphasize different approaches to valuation. One academic member is likely to favor direct application of the Capital Asset Pricing Model (CAPM) to value the field, whereas several others are likely to emphasize a Weighted Average Cost of Capital (WACC) approach.

There are certain to be questions about the choice of discount rates used in the valuation, and about the effect of debt capacity on value. In the past, board members have disagreed over how the tax deductibility of interest expense should affect cost of capital and value. One view is that cost of debt should be determined on an after-corporate tax basis. The other extreme is that the tax benefit at the corporate level is offset by a tax disadvantage at the investor level. The extent to which these views represent a real disagreement, as opposed to just being aspects of different approaches to valuation, is unclear.

One senior member of the board has argued in the past, that you can determine the appropriate bid by a traditional rule-of-thumb approach of simply adding up the projected real cash flows associated with the proved reserves. More sophisticated questions are likely to be raised about whether to value the holding based on real or nominal cash flow projections.

In addition, there are likely to be questions related to how the uncertainty of crude oil prices, combined with ability to adjust production rates, should bear on the valuation. Finally, you recognize that you will be bidding against others, and that the winning bidder is likely to be the one who is most optimistic about the value of the field. In such an environment, how can you balance the objective of winning the bid against the risk of paying more than the field is worth?

The board hopes to complete the deal before mid-year 2000.

Capital Market Analysis

As bases for your study, you have collected information on prevailing interest rates, capital structures of other firms engaged in crude oil extraction, and information relevant to cost of capital determination. This information is summarized in Exhibits 7 and 8.

Exhibit 1

Expected Production Volumes (BOEPD)			
Year	Proved Reserves	Non-Proved Reserves	Total Reserves
2001	68,500	-	68,500
2002	73,000	-	73,000
2003	111,500	7,000	118,500
2004	110,000	22,000	132,000
2005	92,500	38,000	130,500
2006	78,000	49,500	127,500
2007	61,000	58,500	119,500
2008	62,000	63,500	125,500
2009	67,500	59,500	127,000
2010	60,000	60,500	120,500
2011	44,500	68,500	113,000
2012	41,500	67,000	108,500
2013	37,000	65,500	102,500
2014	33,500	65,000	98,500
2015	31,000	62,500	93,500
2016	28,500	59,500	88,000
2017	28,500	51,500	80,000
2018	24,500	50,000	74,500
2019	13,000	44,500	57,500
2020	12,000	40,000	52,000
2021	11,500	36,000	47,500
2022	11,000	32,500	43,500
2023	10,500	18,500	29,000
2024	9,000	17,500	26,500
2025	9,500	15,000	24,500
2026	8,500	13,500	22,000
2027	8,000	12,000	20,000
2028	8,000	10,500	18,500
2029	7,500	9,500	17,000
2030	7,000	9,000	16,000
2031	6,500	8,000	14,500
2032	6,500	6,500	13,000
2033	6,000	6,000	12,000
2034	6,000	5,000	11,000
2035	5,500	5,000	10,500
2036	5,500	4,500	10,000
2037	5,000	4,500	9,500
2038	4,000	5,000	9,000
2039	4,000	4,500	8,500
2040	4,000	4,500	8,500
2041	-	8,000	8,000
2042	-	7,500	7,500
2043	-	7,000	7,000
2044	-	7,000	7,000
2045	-	6,500	6,500
2046	-	6,500	6,500
2047	-	6,500	6,500
2048	-	6,000	6,000
2049	-	6,000	6,000
2050	-	5,500	5,500
2051	-	5,500	5,500
2052	-	5,500	5,500
2053	-	5,000	5,000
2054	-	5,000	5,000
2055	-	4,500	4,500
2056	-	4,500	4,500
2057	-	4,500	4,500
2058	-	4,000	4,000
2059	-	4,000	4,000
2060	-	4,000	4,000
Total			2,494,500

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Exhibit 2

Year	Proved Reserves	Non-Proved Reserves	Total Reserves
Price per BOE (Real)			
2001	$ 12.50	$ -	$ 12.50
2002	$ 13.00	$ -	$ 13.00
2003	$ 13.50	$ 3.90	$ 12.93
2004	$ 13.50	$ 16.20	$ 13.95
2005	$ 13.30	$ 18.00	$ 14.67
2006	$ 13.20	$ 18.80	$ 15.37
2007	$ 13.00	$ 19.00	$ 15.94
2008	$ 12.80	$ 20.00	$ 16.44
2009	$ 12.70	$ 21.00	$ 16.59
2010	$ 12.70	$ 21.70	$ 17.22
2011	$ 12.60	$ 19.50	$ 16.78
2012	$ 12.50	$ 19.10	$ 16.58
2013	$ 12.40	$ 19.00	$ 16.62
2014	$ 12.30	$ 18.70	$ 16.52
2015	$ 12.10	$ 18.60	$ 16.44
2016	$ 11.50	$ 18.60	$ 16.30
2017	$ 11.00	$ 18.50	$ 15.83
2018	$ 10.50	$ 18.50	$ 15.87
2019	$ 10.00	$ 18.50	$ 16.58
2020	$ 9.10	$ 18.40	$ 16.25
2021	$ 8.60	$ 18.40	$ 16.03
2022	$ 8.00	$ 18.40	$ 15.77
2023	$ 7.80	$ 18.30	$ 14.50
2024	$ 7.20	$ 18.30	$ 14.53
2025	$ 7.10	$ 18.30	$ 13.96
2026	$ 7.00	$ 18.30	$ 13.93
2027	$ 6.90	$ 18.00	$ 13.56
2028	$ 6.60	$ 18.00	$ 13.07
2029	$ 6.30	$ 18.00	$ 12.84
2030	$ 6.00	$ 18.00	$ 12.75
2031	$ 5.50	$ 17.50	$ 12.12
2032	$ 5.00	$ 17.50	$ 11.25
2033	$ 4.60	$ 17.00	$ 10.80
2034	$ 4.60	$ 16.50	$ 10.01
2035	$ 4.50	$ 16.50	$ 10.21
2036	$ 4.50	$ 13.00	$ 8.33
2037	$ 4.50	$ 12.50	$ 8.29
2038	$ 4.40	$ 12.50	$ 8.90
2039	$ 4.40	$ 12.20	$ 8.53
2040	$ 4.30	$ 12.00	$ 8.38
2041		$ 10.00	$ 10.00
2042		$ 9.00	$ 9.00
2043		$ 8.00	$ 8.00
2044		$ 7.00	$ 7.00
2045		$ 7.00	$ 7.00
2046		$ 7.00	$ 7.00
2047		$ 7.00	$ 7.00
2048		$ 6.50	$ 6.50
		-	-
2060		$ 6.50	$ 6.50

Exhibit 3

Price Index (Crude Oil Real $/bbl)				Price Index Uncertainty (Crude Oil $/bbl)	
Year	Base Case (Expected Price)	Low Case (25th Percentile)	High Case (75th Percentile)	Low Differential	High Differential
2001	$ 18.64	$ 17.12	$ 20.45	91.85%	109.71%
2002	$ 18.99	$ 15.98	$ 21.59	84.15%	113.69%
2003	$ 19.28	$ 15.54	$ 22.44	80.60%	116.39%
2004	$ 19.50	$ 15.09	$ 23.26	77.38%	119.28%
2005	$ 19.72	$ 14.91	$ 23.47	75.61%	119.02%
2006	$ 19.89	$ 14.79	$ 23.75	74.36%	119.41%
2007	$ 20.03	$ 14.65	$ 24.05	73.14%	120.07%
2008	$ 20.16	$ 14.57	$ 24.43	72.27%	121.18%
2009	$ 20.29	$ 14.49	$ 24.84	71.41%	122.42%
2010	$ 20.41	$ 14.43	$ 25.28	70.70%	123.86%
2011	$ 20.54	$ 14.41	$ 25.76	70.16%	125.41%
2012	$ 20.68	$ 14.41	$ 26.25	69.68%	126.93%
2013	$ 20.79	$ 14.39	$ 26.66	69.22%	128.23%
2014	$ 20.88	$ 14.35	$ 27.07	68.73%	129.65%
2015	$ 20.98	$ 14.32	$ 27.49	68.26%	131.03%
2016	$ 20.98	$ 14.20	$ 27.72	67.68%	132.13%
2017	$ 20.98	$ 14.12	$ 27.93	67.30%	133.13%
2018	$ 20.98	$ 14.06	$ 28.12	67.02%	134.03%
2019	$ 20.98	$ 13.98	$ 28.25	66.63%	134.65%
2020	$ 20.98	$ 13.98	$ 28.25	66.63%	134.65%
2021	$ 20.98	$ 13.98	$ 28.25	66.63%	134.65%
2022	$ 20.98	$ 13.98	$ 28.25	66.63%	134.65%
2023	$ 20.98	$ 13.98	$ 28.25	66.63%	134.65%
2024	$ 20.98	$ 13.98	$ 28.25	66.63%	134.65%
2025	$ 20.98	$ 13.98	$ 28.25	66.63%	134.65%
	-	-	-	-	-
2060	$ 20.98	$ 13.98	$ 28.25	66.63%	134.65%

Exhibit 4

Year	Revenue from Proved Reserves	Revenue from Non-Proved Reserves	Total Revenue
Revenue Projections (Real $000)			
2001	$ 312,531	$ -	$ 312,531
2002	$ 346,385	$ -	$ 346,385
2003	$ 549,416	$ 9,965	$ 559,381
2004	$ 542,025	$ 130,086	$ 672,111
2005	$ 449,041	$ 249,660	$ 698,701
2006	$ 375,804	$ 339,669	$ 715,473
2007	$ 289,445	$ 405,698	$ 695,143
2008	$ 289,664	$ 463,550	$ 753,214
2009	$ 312,896	$ 456,068	$ 768,964
2010	$ 278,130	$ 479,190	$ 757,320
2011	$ 204,656	$ 487,549	$ 692,204
2012	$ 189,344	$ 467,091	$ 656,434
2013	$ 167,462	$ 454,243	$ 621,705
2014	$ 150,398	$ 443,658	$ 594,056
2015	$ 136,912	$ 424,313	$ 561,224
2016	$ 119,629	$ 403,946	$ 523,574
2017	$ 114,428	$ 347,754	$ 462,181
2018	$ 93,896	$ 337,625	$ 431,521
2019	$ 47,450	$ 300,486	$ 347,936
2020	$ 39,858	$ 268,640	$ 308,498
2021	$ 36,099	$ 241,776	$ 277,875
2022	$ 32,120	$ 218,270	$ 250,390
2023	$ 29,894	$ 123,571	$ 153,464
2024	$ 23,652	$ 116,891	$ 140,543
2025	$ 24,619	$ 100,193	$ 124,812
2026	$ 21,718	$ 90,173	$ 111,891
2027	$ 20,148	$ 78,840	$ 98,988
2028	$ 19,272	$ 68,985	$ 88,257
2029	$ 17,246	$ 62,415	$ 79,661
2030	$ 15,330	$ 59,130	$ 74,460
2031	$ 13,049	$ 51,100	$ 64,149
2032	$ 11,863	$ 41,519	$ 53,381
2033	$ 10,074	$ 37,230	$ 47,304
2034	$ 10,074	$ 30,113	$ 40,187
2035	$ 9,034	$ 30,113	$ 39,146
2036	$ 9,034	$ 21,353	$ 30,386
2037	$ 8,213	$ 20,531	$ 28,744
2038	$ 6,424	$ 22,813	$ 29,237
2039	$ 6,424	$ 20,039	$ 26,463
2040	$ 6,278	$ 19,710	$ 25,988
2041	$ -	$ 29,200	$ 29,200
2042	$ -	$ 24,638	$ 24,638
2043	$ -	$ 20,440	$ 20,440
2044	$ -	$ 17,885	$ 17,885
2045	$ -	$ 16,608	$ 16,608
2046	$ -	$ 16,608	$ 16,608
2047	$ -	$ 16,608	$ 16,608
2048	$ -	$ 14,235	$ 14,235
2049	$ -	$ 14,235	$ 14,235
2050	$ -	$ 13,049	$ 13,049
2051	$ -	$ 12,045	$ 12,045
2052	$ -	$ 12,045	$ 12,045
2053	$ -	$ 10,038	$ 10,038
2054	$ -	$ 10,038	$ 10,038
2055	$ -	$ 9,034	$ 9,034
2056	$ -	$ 9,034	$ 9,034
2057	$ -	$ 9,034	$ 9,034
2058	$ -	$ 7,300	$ 7,300
2059	$ -	$ 7,300	$ 7,300
2060	$ -	$ 7,300	$ 7,300
Total	$ 5,339,932	$ 8,200,619	$ 13,540,551

Exhibit 5

Operating Expenses (Real $000)		
	Year	Total Operating Expenses
	2001	$ 50,000
	2002	$ 60,000
	2003	$ 70,000
	2004	$ 60,000
	2005	$ 60,000
	2006	$ 55,000
	2007	$ 55,000
	2008	$ 50,000
	2009	$ 50,000
	2010	$ 50,000
	2011	$ 45,000
	2012	$ 45,000
	2013	$ 45,000
	2014	$ 40,000
	2015	$ 40,000
	2016	$ 40,000
	2017	$ 35,000
	2018	$ 35,000
	2019	$ 35,000
	2020	$ 35,000
	2021	$ 35,000
	2022	$ 35,000
	2023	$ 30,000
	2024	$ 30,000
	2025	$ 30,000
	2026	$ 30,000
	2027	$ 30,000
	2028	$ 30,000
	2029	$ 30,000
	2030	$ 30,000
	2031	$ 30,000
	2032	$ 30,000
	2033	$ 30,000
	2034	$ 30,000
	2035	$ 30,000
	2036	$ 30,000
	2037	$ 30,000
	2038	$ 30,000
	2039	$ 25,000
	2040	$ 25,000
	2041	$ 25,000
	2042	$ 25,000
	2043	$ 25,000
	2044	$ 25,000
	2045	$ 25,000
	2046	$ 25,000
	2047	$ 20,000
	2048	$ 20,000
	2049	$ 20,000
	2050	$ 20,000
	2051	$ 20,000
	2052	$ 20,000
	2053	$ 20,000
	2054	$ 20,000
	2055	$ 20,000
	2056	$ 20,000
	2057	$ 20,000
	2058	$ 15,000
	2059	$ 15,000
	2060	$ 15,000

Exhibit 6

Capital Expenditures (Real $000)		
	Year	**Capital Investment**
	2001	$ -
	2002	$ 50,000
	2003	$ 60,000
	2004	$ 100,000
	2005	$ 120,000
	2006	$ 150,000
	2007	$ 120,000
	2008	$ 100,000
	2009	$ 80,000
	2010	$ 50,000
	2011	$ 40,000
	2012	$ 40,000
	2013	$ 40,000
	2014	$ 40,000
	2015	$ 30,000
	2016	$ -
	2017	$ -
	2018	$ -
	-	$ -
	2060	$ -

Exhibit 7

Market Information	
Risk Free Rate (Note 1)	6.50%
Expected Annual Inflation (Note 2)	3.20%
High-grade Long-term Corporate Debt Rate (Note 3)	7.70%
Market Risk Premium (Note 4)	7.50%

Notes:

[1]Currently available yield on 10-year Treasury bonds.

[2]Market expectation of long-term inflation rate, inferred from market data on the yield differential between long-term inflation-indexed Treasury bonds, and equivalent-maturity non-indexed Treasury bonds.

[3]Estimate of currently available yield on newly-issued Moody's Aaa-rated non-callable long-term corporate debt.

[4]Long-term historical risk-premium of the S&P 500 Stock Index over the historical return on 10-year Treasury bonds.

Exhibit 8

		Estimated Equity Beta	Shares Outstanding (millions)	Price per Share ($)	Total Equity ($ millions)	Total Debt ($ millions)	Total Capitalization ($ millions)	Percent Equity	Percent Debt	Estimated Debt Beta	Estimated Asset Beta
	Comparable Oil Company Data										
1	Company A	0.77	119.77	30.344	3,634.27	1,645.45	5,279.72	0.688	0.312	0.000	0.530
2	Company B	0.37	93.31	35.063	3,271.68	2,082.87	5,354.55	0.611	0.389	0.100	0.265
3	Company C	0.55	176.71	44.813	7,918.82	2,267.00	10,185.82	0.777	0.223	0.000	0.428
4	Company D	0.58	24.67	19.438	479.52	287.87	767.39	0.625	0.375	0.100	0.400
5	Company E	0.88	39.45	16.625	655.86	563.32	1,219.18	0.538	0.462	0.200	0.566
6	Company F	0.71	48.29	38.500	1,859.17	122.51	1,981.68	0.938	0.062	0.000	0.666
7	Company G	0.37	37.32	16.500	615.78	306.55	922.33	0.668	0.332	0.100	0.280
8	Company H	0.38	9.89	8.375	82.83	36.17	119.00	0.696	0.304	0.000	0.264
9	Company I	0.48	4.89	10.250	50.12	18.88	69.00	0.726	0.274	0.000	0.349
10	Company J	0.51	35.98	23.313	838.78	197.18	1,035.96	0.810	0.190	0.000	0.413
11	Company K	0.98	105.98	25.500	2,702.49	1,573.00	4,275.49	0.632	0.368	0.100	0.656
12	Company L	0.77	33.55	29.500	989.73	420.34	1,410.07	0.702	0.298	0.000	0.540
13	Company M	0.25	102.94	11.250	1,158.08	200.20	1,358.28	0.853	0.147	0.000	0.213
	Arithmetic Average	0.58						0.713	0.287	0.046	0.429
	25th percentile	0.38						0.632	0.223	0.000	0.280
	75th percentile	0.77						0.777	0.368	0.100	0.540