

WORLDWIDE PETROLEUM CONSULTANTS

## Introduction to Estimation of Oil and Gas Reserves

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NTCHBA Conference September 29, 2025



## What Are Hydrocarbon Reserves?

"Reserves are those quantities of petroleum anticipated to be commercially recoverable by application of development projects to known accumulations [hydrocarbon reservoirs] from a given date forward under defined conditions."

Therefore, all reserves volumes **MUST** be:

- 1. Economic to produce
- 2. Associated with a firm development plan
- 3. "Discovered"
- 4. Remaining recoverable from a certain date



Petroleum Reserves and Resources Classification and Definitions (Excerpted from the Petroleum Resources Management System approved by the Society of Petroleum Engineers (SPE) Board of Directors, June 2018)



## Why are Reserves Volumes Relevant to Fair Market Value?

Reserves estimation typically requires a combination of:

- Geologic analysis of the hydrocarbon volumes originally in place
- Engineering analysis of production potential based on operator's development plan
- Economic analysis and cash flow modelling to confirm economic viability

Therefore, all reserves evaluations produce:

- 1. Forecast of future sales volumes
- 2. Field-level cash flow model

A cash flow model incorporating both the physical and economic constraints of hydrocarbon production are critical to valuation of hydrocarbon assets



## Reserves Are Categorized by Certainty of Recovery



#### **Proved**

- Lowest risk category, reasonable certainty of recovery under current economic conditions
- SEC defines reasonable certainty as "much more likely to be achieved than not"

#### **Probable**

- Moderate risk categorization
- Proved + Probable reserves have equally likely chance of being recovered as not ("most likely")

#### **Possible**

More speculative, low degree of certainty



## Why Do We Need Reserves Definitions?

- To quantify the range of uncertainty of recoverable hydrocarbons
- To standardize classification of reserves/resources within the petroleum industry
- To provide capital markets with consistent standards for asset valuation



## **Authorities in Reserves/Resources Categorization**

- Securities and Exchange Commission (SEC)
- Canadian Securities Administrators (CSA NI 51-101)
- Petroleum Resource Management System (PRMS)
  - Society of Petroleum Engineers (SPE)
  - American Association of Petroleum Geologists (AAPG)
  - World Petroleum Council (WPC)
  - Society of Petroleum Evaluation Engineers (SPEE)
- Various foreign governments, professional societies, and financial markets (typically refer to PRMS definitions)





## When & Why Are Reserves Reports Prepared?

#### **External**

- Security filings (SEC, International Exchanges London, Hong Kong, Singapore)
- Public disclosure (press releases, annual reports)
- External financing/joint ventures/privatization
- Property sales/acquisition diligence
- Unitizations/equity determinations
- Reports for governmental agencies (foreign and domestic)

#### Internal

- Corporate planning and financial decisions
- Accounting requirements such as depletion calculations, etc.
- Monitoring success of exploration and acquisition programs

Regardless of the ultimate audience... independence of the evaluator is key.



## **Example - Report Letter**

#### **Estimates of Reserves and Revenue**

NSA WORLDWIDE

Mr. Edwin Drak Big Strike Oil Co

100 Main Street Titusville, Penn

Dear Mr. Drake

In accordance revenue, as of

properties locate

evaluation on o

specified by Bi

been prepared Management S immediately foll

December 31, 20

			Net F	Reserves	Future Net	Revenue (M\$)
	Catego	ory	Oil (MBBL)	Gas (MMCF)	Total	Present Wor at 10%
Prove	d Developed   d Developed   d Undevelope	Non-Producing	6,337.6 67.1 9,318.3	10,307.6 51.3 13,935.5	124,089.5 702.1 160,533.1	67,507.5 218.7 37,584.7
Tota	I Proved		15,7231.1	24,294.3	285,324.7	105,310.9
Proba	ble		4,026.7	6,016.3	58,192.5	10,320.6
Possib	ole		71,027.5	106,151.6	998,233.6	209,077.8
Category reloped Producing reloped Non-Producing developed	Net Reserves   Gas   (MMCF)   Gas   (MMCF)   G,337.6   10,307.6   67.1   51.3   9,318.3   13,935.5	Future Net Revenue (MS) Total Present Worth at 10%  124,089.5 67,507.5 702.1 218.7 160,533.1 37,584.7		52.85 2.797 53.10 2.896 53.14 3.013 53.06 3.107 52.98 3.196 berating expense records of Big Strike. These contenting agreements along with estimates of costs	d engineering and halysis, analogy, 2 ze, and estimate and gas evalua therefore, our costs include the	of Oil and Gas Reserves information pro- igeoscience methods, or a combination and reservoir modeling, that we consider reserves in accordance with the 2018 tion, there are uncertainties inherent in nuclusions necessarily represent only

	Net Re	eserves	Future Net	Revenue (MS)
Category	Oil (MBBL)	Gas (MMCF)	Total	Present Worth at 10%
Proved Developed Producing Proved Developed Non-Producing Proved Undeveloped	6,337.6 67.1 9,318.3	10,307.6 51.3 13,935.5	124,089.5 702.1 160,533.1	67,507.5 218.7 37,584.7
Total Proved	15,7231.1	24,294.3	285,324.7	105,310.9
Probable	4,026.7	6,016.3	58,192.5	10,320.6
Possible	71,027.5	106,151.6	998,233.6	209,077.8

The oil volumes shown include crude oil, condensate, and natural gas liquids (NGL). Oil volumes are expressed in thousands of barrels (MBBL); a barrel is equivalent to 42 United States callons. Gas volumes are expressed in millions of cubic feet (MMCF) at standard temperature and pressure bases. Oil equivalent volumes shown in this report are expressed in thousands of barrels of oil equivalent (MBOE), determined using the ratio of 6 MCF of gas

Reserves categorization conveys the relative degree of certainty; reserves subcategorization is based on development and production status. The estimates of reserves and future revenue included herein have not been adjusted for risk. This report does not include any value that could be attributed to interests in undeveloped acreage beyond those tracts for which undeveloped reserves have been estimated

As shown in the Table of Contents, this report includes summary projections of reserves and revenue by reserves category. Also included are reserves and economics data for each reserves category; these data include a summary projection of reserves and revenue along with one-line summaries of basic data, reserves, and economics

Gross revenue shown in this report is Big Strike's share of the gross (100 percent) revenue from the properties prior to any deductions. Future net revenue is after deductions for Big Strike's share of production taxes, ad valorem

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the district and field levels. Operating costs have been divided into field-level costs, per-well costs, f-production costs. Headquarters general and administrative overhead expenses of Big Strike are e extent that they are covered under joint operating agreements for the operated properties. As erating costs are not escalated for inflation.

used in this report were provided by [company] and are based on authorizations for expenditure and om recent activity. Capital costs are included as required for workovers, new development wells, and ipment. Based on our understanding of future development plans, a review of the records provided r knowledge of similar properties, we regard these estimated capital costs to be reasonable. costs used in this report are Big Strike's estimates of the costs to abandon the wells, platforms, and ilities, net of any salvage value. As requested, capital costs and abandonment costs are not escalated

ses of this report, we did not perform any field inspection of the properties, nor did we examine the peration or condition of the wells and facilities. We have not investigated possible environmental to the properties; therefore, our estimates do not include any costs due to such possible liability.

de no investigation of potential volume and value imbalances resulting from overdelivery or to the Big Strike interest. Therefore, our estimates of reserves and future revenue do not include r the settlement of any such imbalances; our projections are based on Big Strike receiving its net st share of estimated future gross production. Additionally, we have made no specific investigation apportation contracts that may be in place for these properties; our estimates of future revenue include such contracts only to the extent that the associated fees are accounted for in the historical field- and

shown in this report are estimates only and should not be construed as exact quantities. Proved those quantities of oil and gas which, by analysis of engineering and geoscience data, can be

geoscience methods, or a combination of methods, including and reservoir modeling, that we considered to be appropriate reserves in accordance with the 2018 PRMS definitions and tion, there are uncertainties inherent in the interpretation of onclusions necessarily represent only informed professional

**Present Worth** at 10%

actual e based

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re obtained from Big Strike, other interest owners, various operators of the d the nonconfidential files of Netherland, Sewell & Associates, Inc. and were work data are on file in our office. We have not examined the titles to the ed the actual degree or type of interest owned. The technical persons primarily imates presented herein meet the requirements regarding qualifications, identiality set forth in the SPE Standards. We are independent petroleum and petrophysicists; we do not own an interest in these properties nor are we

NETHERLAND, SEWELL & ASSOCIATES, INC. Texas Registered Engineering Firm F-2699

C.H. (Scott) Rees III, P.E.

Chairman and Chief Executive Officer

Geologist, P.G. 11111

Date Signed: April 12, 2019





## **Example - Summary Table**

#### **Reserves and Gross Revenue**

NSA	NETHERLA & ASSOCIA														
				SUI	MMARY PROJECTI			UE			CERT	AIN PROPERTIE	SLOCATEDIN		
BIG STRIKE OIL C	AS OF DECEMBER 31, 2018 CERTAIN PROPERTIES LOCATED IN KANSAS, LOUISIANA, AND TEXAS  IG STRIKE OIL CORPORATION INTEREST  KANSAS, LOUISIANA, AND TEXAS														
BIG STRIKE OIL CORPORATION INTEREST  KANSAS, LOUISIANA, AND TEXAS  TOTAL PROVED RESERVES															
PERIOD	GROSS RES	SERVES		NET RESE	RVES		AVE	ERAGE PRICE	s		GROSS RE	VENUE			
ENDING	OIL	GAS	OIL	NGL	GAS	EQUIV	OIL	NGL	GAS	OIL	NGL	GAS	TOTAL		
M-D-Y MBBL MMCF MBBL MBBL MMCF MBOE \$/BBL \$//BBL \$//AICF M\$ M\$ M\$ M\$															
12-31-2019	1,038.3	1,796.0	608.6	0.0	1,027.0	779.8	42.69	0.00	1.651	25,980.3	0.0	1,696.0	27,676.3		

PERIOD	GROSS RES	ERVES			NET RE	SERVES			AVE	RAGE PRICE	S		GROSS RE	VENUE	
ENDING	OIL	GAS		OIL	NGL	GA	AS	EQUIV	OIL	NGL	GAS	OIL	NGL	GAS	TOTAL
M-D-Y	MBBL	MMCF		MBBL	MBBL	MM	CF	MBOE	\$/BBL	\$/BBL	\$/MCF	M\$	М\$	M\$	M\$
12-31-2019	1,038.3	1,79	6.0	608.6	0.0		1,027.0	779.8	42.69	0.00	1.651	25,980.3	0.0	1,696.0	27,676
12-31-2020	1,504.8	2,27	4.8	883.3	0.0		1,310.3	1,101.7	44.75	0.00	1.381	39,523.8	0.0	1,809.2	41,333
12-31-2021	1,727.6	2,52	0.5	1,103.0	0.0		1,556.4	1,362.4	46.13	0.00	1.319	50,881.2	0.0	2,053.5	52,934
12-31-2022	1,722.6	2,58	2.7	1,087.5	0.0		1,596.4	1,353.5	47.15	0.00	1.455	51,274.0	0.0	2,322.6	53,596
12-31-2023	1,541.1	2,34	8.7	854.2	0.0		1,314.1	1,073.2	47.98	0.00	1.520	40,983.6	0.0	1,997.1	42,980
12-31-2024	1,755.1	2,56	3.4	1,066.3	0.0		1,525.7	1,320.6	48.69	0.00	1.685	51,914.3	0.0	2,571.1	54,485
12-31-2025	1,846.5	2,71	4.7	1,075.3	0.0		1,576.7	1,338.1	48.96	0.00	1.964	52,645.9	0.0	3,096.4	55,742
12-31-2026	1,390.4	2,18	1.5	812.6	0.0		1,264.3	1,023.3	48.93	0.00	2.027	39,761.1	0.0	2,563.1	42,324
12-31-2027	1,792.6	2,60	8.2	868.6	0.0		1,307.5	1,086.5	48.89	0.00	2.095	42,467.9	0.0	2,739.5	45,207
12-31-2028	1,542.1	2,34	3.8	710.4	0.0		1,123.6	897.7	48.77	0.00	2.196	34,647.1	0.0	2,467.2	37,114
12-31-2029	1,444.8	2,23	5.5	619.4	0.0		1,000.2	786.1	48.74	0.00	2.288	30,188.3	0.0	2,287.9	32.476
12-31-2030	1,156.1	1,85	9.6	545.0	0.0		888.9	693.2	48.72	0.00	2.372	26,552.1	0.0	2,108.2	28,660
12-31-2031	1,002.7	1,63	5.0	490.3	0.0		803.3	624.2	48.70	0.00	2.464	23,876.7	0.0	1,979.0	25,855
12-31-2032	896.0	1,47	6.9	446.8	0.0		736.1	569.5	48.69	0.00	2.453	21,754.1	0.0	1,805.4	23.559
12-31-2033	808.2	1,33	9.6	409.1	0.0		675.7	521.8	48.69	0.00	2.450	19,920.0	0.0	1,655.5	21,575
UBTOTAL	21,168.8	32,48	1.0	11,580.4	0.0		17,706.2	14,531.4	47.70	0.00	1.872	552,370.3	0.0	33,151.6	585,521
EMAINING	8,132.2	13,27	4.8	4,142.7	0.0		6,588.1	5,240.7	48.68	0.00	2.523	201,655.8	0.0	16,621.3	218,277
OTAL	29,301.0	45,75	5.8	15,723.1	0.0		24,294.3	19,772.1	47.96	0.00	2.049	754,026.0	0.0	49,772.9	803,798
UM PROD	13,872.0	17,32	8.4												
LTIMATE	43,173.0	63,08	4.1												
	12-31-2027	113	79.0	3,787.7	0.0	9,431.3	60.8	13,662.2	18,265.4	111,26			80.000	6,944.8	
	12-31-2028	112	76.1	3,049.4	0.0	1,020.0	213.5	12,467.3	20,364.1	131,62			100.000	5,167.7	
	12-31-2029 12-31-2030	112 112	76.1 76.1	2,638.2 2,302.3	0.0	0.0	0.0	11,728.1 10,867.8	18,109.9 15,490.1	149,73 165,22					
	12-31-2031	108	73.5	2,059.1	0.0	0.0	264.5	10,164.4	13,367.7	178,59					
	12-31-2032	105	71.1	1,868.4	0.0	0.0	242.9	9,595.9	11,852.3	190,44					
	12-31-2033	102	69.5	1,703.0	0.0	0.0	160.9	9,051.3	10,660.3	201,10					
	SUBTOTAL			46,023.3	0.0	147,179.2	1,734.6	189,478.4	201,106.3	201,10					
	REMAINING TOTAL OF 50.0 YRS			16,424.6 62,447.9	0.0	0.0 147,179.2	6,945.7 8,680.3	110,688.3 300,166.7	84,218.4 285,324.7	285,32 285,32					



## **Example - Summary Table**

#### **Expenses and Net Revenue**

NSA		ND, SEWELL ATES, INC.													
SUMMARY PROJECTION OF RESERVES AND REVENUE  AS AS DECEMBER 31 2019  CERTAIN PROPERTIES LOCATED IN															
	AS OF DECEMBER 31, 2018  CERTAIN PROPERTIES LOCATION  AS OF DECEMBER 31, 2018  CERTAIN PROPERTIES LOCATION  AS OF DECEMBER 31, 2018														
BIG STRIKE OIL C	SIG STRIKE OIL CORPORATION INTEREST KANSAS, LOUISIANA, AND TEXAS														
	TOTAL PROVED RESERVES														
PERIOD	GROSS RE	SERVES		NET RES	ERVES		AV	ERAGE PRICI	ES	2	GROSS RE	VENUE			
ENDING OIL GAS OIL NGL GAS EQUIV OIL NGL GAS OIL NGL GAS TOTAL															
M-D-Y	MBBL	MMCF	MBBL	MBBL	MMCF	MBOE	\$/BBL	\$/BBL	\$/MCF	M\$	M\$	M\$	M\$		
12-31-2019															

				NET DED	UCTIONS/EXP	ENDITURES		FL	JTURE NET REVEN	IUE			
PERIOD	NUMBER Ó	F	TAX	ŒŞ	CAPITAL	ABDNMNT	OPERATING	UNDISC	COUNTED	DISC AT 10.000%	Р	RESENT WOR	TH PROFILE
ENDING	ACTIVE COMPLE	TIONS	PRODUCTION	AD VALOREM	COST	COST	EXPENSE	PERIOD	CUM	CUM	DIS	SC RATE	CUM PW
M-D-Y	GROSS	NET	M\$	M\$	M\$	M\$	М\$	M\$	M\$	MS		%	М\$
12-31-2019	85	60.6	2,413.8	0.0	9,641	.5 323.1	11,451.7	3,846.2	3,846.2	3,922.1		8.000	124,46
12-31-2020	90	64.4	3,815.1	0.0	19,595	.1 270.0	13,286.4	4,366.4	8,212.6	7,215.6		12.000	90,13
12-31-2021	97	70.8	3,397.5	0.0	48,610	.7 73.1	14,894.8	-14,041.3	-5,828.7	-4,324.4		15.000	72,68
12-31-2022	98	71.3	3,426.5	0.0	3,400	.0 0.0	15,291.8	31,478.3	25,649.6	18,240.6		20.000	52,83
12-31-2023	101	72.0	3,051.7	0.0	5,015	.0 0.0	13,566.4	21,347.6	46,997.2	32,069.0		25.000	39.93
12-31-2024	107	77.3	4,422.0	0.0	35,672	.0 0.0	14,830.1	-438.7	46,558.5	31,521.5		30.000	31,14
12-31-2025	109	78.3	4,649.2	0.0	10,200	.0 51.1	15,273.1	25,568.9	72,127.4	45,151.1		40.000	20.36
12-31-2026	108	77.5	3,439.6	0.0	4.593	.8 74.7	13,347.2	20,869.0	92,996.4	55,490.3		60.000	10.76
12-31-2027	113	79.0	3,787.7	0.0	9.431	.3 60.8	13,662.2	18,265.4	111,261.8	63,512.7		80.000	6.94
12-31-2028	112	76.1	3,049.4	0.0	1.020		12,467.3	20,364.1	131,625.9	71,771.4	1	00.000	5.16
12-31-2029	112	76.1	2,638.2	0.0	12,400,000	.0 0.0	11,728.1	18.109.9	149.735.8	78,440.9			
12-31-2030	112	76.1	2.302.3	0.0		.0 0.0	10,867.8	15,490.1	165,225.9	83,625.2			
12-31-2031	108	73.5	2,059.1	0.0		.0 264.5	10,164.4	13,367.7	178,593.6	87,690.7			
12-31-2032	105	71.1	1.868.4	0.0		.0 242.9	9,595.9	11,852.3	190,446.0	90,968.4			
12-31-2033	102	69.5	1,703.0	0.0		.0 160.9	9,051.3	10,660.3	201,106.3	93,648.0			
12 01 2000	102	00.0	1,700.0	0.0		.00.0	0,001.0	10,000.0	201,100.0	00,0-0.0			
UBTOTAL			46,023.3	0.0	147,179	.2 1,734.6	189,478.4	201,106.3	201,106.3	93,648.0			
EMAINING			16,424.6	0.0	C	.0 6,945.7	110,688.3	84,218.4	285,324.7	105,310.9			
DTAL OF 50.0 Y	'RS		62,447.9	0.0	147,179		300,166.7	285,324.7	285,324.7	105,310.9			
	10 04 0000	100	77.5	-1,540.2	0.0		10,217.0	20,000.0	00.000.4	40,101.1	-10.000	10,704.0	
	12-31-2026 12-31-2027	108 113	77.5 79.0	3,439.6 3,787.7		5,593.8 74.7 0,431.3 60.8		20,869.0 18,265.4		55,490.3 63,512.7	60.000 80.000	10,761.2 6,944.8	
	12-31-2028	112	76.1	3,049.4		,020.0 213.5		20,364.1		71,771.4	100.000	5,167.7	
	12-31-2029	112	76.1	2,638.2	0.0	0.0	11,728.1	18,109.9	149,735.8	78,440.9			
	12-31-2030	112	76.1	2,302.3	0.0	0.0		15,490.1		83,625.2			
	12-31-2031	108	73.5	2,059.1	0.0	0.0 264.5		13,367.7		87,690.7			
	12-31-2032 12-31-2033	105 102	71.1 69.5	1,868.4 1,703.0	0.0	0.0 242.9 0.0 160.9		11,852.3 10.660.3		90,968.4 93,648.0			
	SUBTOTAL			46,023.3		,179.2 1,734.6		201,106.3		93,648.0			
	REMAINING TOTAL OF 50.0 YRS			16,424.6 62,447.9	0.0	0.0 6,945.7 7.179.2 8,680.3	110,688.3 300,166.7	84,218.4 285,324.7		05,310.9 05,310.9			



## **Example - One-line Summaries**

**Basic Data** 

В	IG STRIKE	E OIL CORPORATION IN	NTEREST					AS	BASIC OF DECEM		18							IN PROPERT		
							PR	ROVED DEV	/ELOPED P	RODUCING	RESERVE	S								
	LEASE		(	ACTI		GROSS UL	TIMATE	WOR		REVE		OIL \$/BB		NGL \$/BBL		GAS \$/MC		ROSS OPERA		LIFE
1	NUMBER	LEASE NAME		DIL _	GAS	MBBL	MMCF	START	END	START	END	START	END	START	END	START	END S	START E	ND _	YRS
								HAS	KELL COU	NTY, KANS	AS									
		ER FIELD, HASKELL CO	YTNUC																	
	003023	PDP 014		1	0	439.3	903.9	90.000	90.000	74.871	74.871	41.88	47.43	0.00	0.00	2.790	3.388	8.4	5.3	30.6
	003025	PDP 015 PDP 016		1	0	139.6 109.6	665.7 929.4	90.000 84.485	90.000 84.485	90.000 73.925	90.000 73.925	41.88 41.88	47.43 47.43	0.00	0.00	2.790 2.790	3.388	3.7 4.7	3.1 3.8	23.3 18.2
	003031	PDP 017		0	0	93.7	376.5	45.000	45.000	37.125	37.125	41.88	41.88	0.00	0.00	2.790	2.790	2.8	2.8	0.0
	003043	PDP 018		1	0	230.6	282.3	90.000	90.000	90.000	90.000	41.88	47.43	0.00	0.00	2.790	3.388	8.9	7.9	19.5
			ACT	TIVE		GROSS ULTIM	IATE	WORK	ING	REVE	NUE	OI	L	NG	iL	8	GAS	GROSS C	PERATIN	IG
LEASE			COME	PLTNS		OIL	GAS	INTERE	ST	INTER	EST	\$/B	BL	\$/B	BL	\$	/MCF	EXPEN	SE M\$/M	L
NUMBE	R	LEASE NAME	OIL	GAS	s	MBBL	MMCF 5	START	END	START	END	START	END	START	END	START	END	START	END	Y
								HASK	ELL COUN	ITY, KANS	AS									
LAD	NER EIEI	D. HASKELL COUNTY	,																	
03023	PDP (		1		ο	439.3	903.9	90.000	90.000	74.871	74.871	41.88	47.43	0.00	0.00	2.79	0 3.388	3 8.4		5.3
03025	PDP (		1		o o	139.6	665.7	90.000	90.000	90.000	90.000	41.88	47.43	0.00	0.00					3.1
003031	PDP 0	016	1		0	109.6	929.4	84.485	84.485	73.925	73.925	41.88	47.43	0.00	0.00	2.79	0 3.388	3 4.7		3.8
03032	PDP (	017	0		0	93.7	376.5	45.000	45.000	37.125	37.125	41.88	41.88	0.00	0.00	2.79				2.8
03043	PDP (	018	1		0	230.6	282.3	90.000	90.000	90.000	90.000	41.88	47.43	0.00	0.00	2.79	0 3.388	8.9		7.9
03059	PDP (	021	1		0	847.7	966.5	90.000	90.000	90.000	90.000	41.88	47.43	0.00	0.00	2.79	0 3.388	3 7.0		5.7
03060	PDP 0	022	1		0	237.7	340.7	90.000	90.000	79.665	79.665	41.88	47.43	0.00	0.00	2.79	0 3.388	6.8		6.0
	FIELD	TOTAL	6		0	2,098.2	4,465.0													
		FIELD TOTAL	0,000	8	0	2,535.5	1,869.0													
		ARISH TOTAL		8	0	2,535.5	1,869.0													
		ANION TOTAL		0	U	2,000.0	1,000.0	MIC	DLAND COL	INTY TEXA	S									
	SPPA	BERRY FIELD, MIDLANI	D COLINTY					WILL												
(	003019	PDP 001	2 3001111	0	0	52.6	90.1	77.754	77.754	64.031	64.031	41.88	41.88	0.00	0.00	1.490	1.490	8.7	8.7	0.0
9	03020	PDP 002		1	0	188.8	308.7	81.269	81.269	66.609	66.609	41.88	47.43	0.00	0.00	1.490	1.992	17.6	12.2	11.3
	003037	PDP 005		1	0	247.7	142.6	66.375	66.375	54.009	54.009	41.88	47.43	0.00	0.00	1.490	2.088	6.2	3.0	31.7
(	003048	PDP 009		1	0	167.6	280.0	2.431	2.431	2.054	2.054	43.58	49.13	0.00	0.00	1.490	2.088	13.3	9.2	14.0
100	002007	PDP 019		0	0	180.9	229.9	67.500	67.500	54.000	54.000	0.00	0.00	0.00	0.00	0.000	0.000	1.4	1.4	0.0
	002017	PDP 020		1	0	117.7	253.8	67.500	67.500	54.000	54.000	43.58	49.21	0.00	0.00	1.490	1.707	3.5	1.5	8.3
33	001028	PDP 023		1	0	388.1	461.9	81.048	81.048	63.895	63.895	43.58	49.13	0.00	0.00	1.490	2.088	17.5	7.4	29.2
	003003	PDP 024		1	0	220.5	243.1	68.983	68.983	59.080	59.080	43.55	49.10	0.00	0.00	1.490	2.088	19.6	10.2	17.0
53	003004	PDP 025 PDP 026		1	0	160.2 230.9	255.1 392.9	68.983	68.983	59.080 59.080	59.080 59.080	43.55 43.55	49.10 49.10	0.00	0.00	1.490	2.088	17.6 18.8	10.1 9.5	14.8
	003005	PDP 026 PDP 027		1	0	399.5	392.9 450.6	68.983 90.000	68.983 90.000	72.881	72.881	43.33	48.88	0.00	0.00	1.490	2.088	21.9	6.5	37.3
- 1	002033	PDP 027 PDP 028		1	0	461.0	877.0	59.545	59.545	46.757	46.757	43.58	49.13	0.00	0.00	1.490	2.088	24.6	10.6	26.8
	02040	PDP 029		1	0	317.1	504.3	59.545	59.545	46.757	46.757	43.58	49.13	0.00	0.00	1.490	2.088	23.6	11.9	18.2
	002040	PDP 030		4	0	344.6	493.0	89 193	89 193	70.634	70.634	43.58	49 13	0.00	0.00	1.490	2.000	20.4	10.5	24.5

002042 PDP 031

11.5 21.5

1.490

0.00

0.00



## **Example - One-line Summaries**

#### **Reserves and Economics**

BIG STRIKE OIL CORPORATION INTERES	т			F	AS	ERVES AND E OF DECEMBE ELOPED PRO	R 31, 2018						77000000	PROPERTIES , LOUISIANA,	
LEASE NUMBER LEASE NAME	GROSS RES	GAS MMCF	OIL MBBL	NET RES NGL MBBL	GAS MMCF	EQUIV MBOE	GRO OIL M\$	NGL M\$	GAS M\$	TOTAL TAXES M\$	NET CAP COST M\$	ABDNMNT COST M\$	OPERATING EXPENSE M\$	NET REVENUE M\$	CUM P.W. 10.000% M\$
					HAS	KELL COUNT	, KANSAS								
LADNER FIELD, HASKELL COUNTY															
003023 PDP 014	130.2	353.9	97.5	0.0	264.9	141.7	4,528.7	0.0	797.4	245.1	0.0	90.0	2,027.0	2,964.0	1,581.
03025 PDP 015	16.9	186.1	15.2	0.0	167.5	43.1	708.6	0.0	512.1	47.2	0.0	90.0	836.0	247.5	162
003031 PDP 016	20.1	213.5	14.8	0.0	157.8	41.1	686.7	0.0	462.8	45.5	0.0	84.5	773.9	245.6	187
003032 PDP 017	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.0	0.0	-45.0	-41
003043 PDP 018	74.5	83.4	67.1	0.0	75.0	79.6	3,100.5	0.0	220.9	160.3	0.0	90.0	1,739.5	1,331.6	866

		GROSS RE	SERVES		NET RES	ERVES	3790	GRO	SS REVENU	JE	TOTAL	NET CAP	ABDNMNT	OPERATING	NET	CUM P.W.
LEASE		OIL	GAS	OIL	NGL	GAS	EQUIV	OIL	NGL	GAS	TAXES	COST	COST	EXPENSE	REVENUE	10.000%
NUMBER	LEASE NAME	MBBL	MMCF	MBBL	MBBL	MMCF	MBOE	M\$	M\$	M\$	M\$	M\$	M\$	M\$	M\$	M\$
						HAS	KELL COUNT	Y, KANSAS								
LADN	IER FIELD, HASKELL COUNTY															
003023	PDP 014	130.2	353.9	97.5	0.0	264.9	141.7	4,528.7	0.0	797.4	245.1	0.0	90.0	2,027.0	2,964.0	1,581.7
003025	PDP 015	16.9	186.1	15.2	0.0	167.5	43.1	708.6	0.0	512.1	47.2	0.0	90.0	836.0	247.5	162.5
003031	PDP 016	20.1	213.5	14.8	0.0	157.8	41.1	686.7	0.0	462.8	45.5	0.0	84.5	773.9	245.6	187.2
003032	PDP 017	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.0	0.0	-45.0	-41.1
003043	PDP 018	74.5	83.4	67.1	0.0	75.0	79.6	3,100.5	0.0	220.9	160.3	0.0	90.0	1,739.5	1,331.6	866.8
003059	PDP 021	230.4	276.3	207.4	0.0	248.6	248.8	9,705.1	0.0	777.4	988.0	0.0	90.0	3,265.7	6,138.8	2,464.1
003060	PDP 022	57.6	90.8	45.9	0.0	72.4	57.9	2,133.5	0.0	215.9	111.8	0.0	90.0	1,495.8	651.9	409.1
	FIELD TOTAL	529.7	1,203.9	447.8	0.0	986.3	612.2	20,863.2	0.0	2,986.5	1,597.9	0.0	579.5	10,137.9	11,534.3	5,630.4

3-000, 3000	FIELD TOTAL	1,171.8	926.5	821.1	0.0	595.3	920.4	35,656.0	0.0	1,895.8	2,619.9	0.0	716.0	11,190.7	23,025.3	8,749.1
P	ARISH TOTAL	1,171.8	926.5	821.1	0.0	595.3	920.4	35,656.0	0.0	1,895.8	2,619.9	0.0	716.0	11,190.7	23,025.3	8,749.1
						MIDLA	ND COUNT	Y, TEXAS								
SPRA	ABERRY FIELD, MIDLAND COL	YTAL														
003019	PDP 001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.8	0.0	-77.8	-71.0
003020	PDP 002	63.4	168.9	42.2	0.0	112.5	61.0	1,933.7	0.0	164.7	201.3	0.0	81.3	1,598.2	217.5	194.7
003037	PDP 005	106.5	68.9	57.5	0.0	37.2	63.7	2,662.6	0.0	62.5	268.9	0.0	66.4	944.5	1,445.3	811.7
003048	PDP 009	65.6	140.6	1.3	0.0	2.9	1.8	64.1	0.0	4.4	6.6	0.0	2.4	43.1	16.4	12.7
002007	PDP 019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
002017	PDP 020	24.8	13.0	13.4	0.0	7.0	14.6	615.4	0.0	9.5	62.0	0.0	67.5	132.1	363.3	329.1
001028	PDP 023	198.7	264.5	127.0	0.0	169.0	155.1	6,111.7	0.0	289.0	623.1	0.0	81.0	2,969.3	2,727.3	1,461.1
003003	PDP 024	99.3	119.7	58.6	0.0	70.7	70.4	2,799.0	0.0	107.8	284.9	0.0	69.0	1,891.8	661.1	472.9
003004	PDP 025	74.4	154.8	44.0	0.0	91.5	59.2	2,096.3	0.0	142.3	216.1	0.0	69.0	1,571.3	382.3	290.8
003005	PDP 026	105.9	251.5	62.6	0.0	148.6	87.3	2,988.6	0.0	241.7	309.3	0.0	69.0	1,979.2	872.8	591.8
003133	PDP 027	297.2	336.0	216.6	0.0	244.9	257.4	10,353.9	0.0	417.9	17.3	0.0	90.0	3,747.1	6,917.4	3,527.0
002033	PDP 028	232.3	596.4	108.6	0.0	278.9	155.1	5,217.0	0.0	472.7	541.4	0.0	59.5	2,804.0	2,284.8	1,283.7
002040	PDP 029	136.0	303.5	63.6	0.0	141.9	87.3	3,037.0	0.0	229.4	313.7	0.0	59.5	2,061.2	831.9	574.6
002041	PDP 030	195.9	350.8	138.4	0.0	247.8	179.7	6,648.0	0.0	413.7	682.3	0.0	89.2	3,585.6	2,704.5	1,576.0
002042	PDP 031	167.4	348.5	78.3	0.0	162.9	105.4	3,755.4	0.0	267.6	387.0	0.0	59.5	2,426.0	1,150.4	704.8

# Reserves Reports Are Not Created Equal

- All reserves definitions leave significant latitude for interpretation and judgment to the evaluator
- Reserves evaluations can vary widely in their scope and depth of investigation
- Forward looking economic assumptions, especially commodity price, can have a significant impact on volumes and value

#### Therefore:

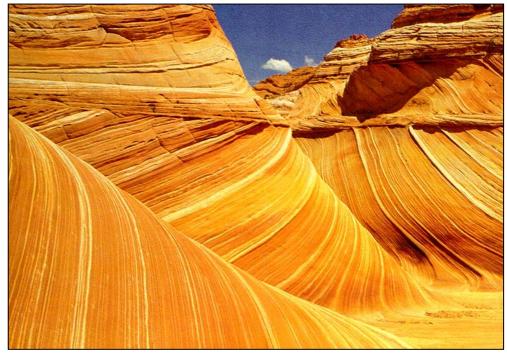
- 1. Reputation, expertise, and independence of the evaluator are critical to report reliability
- 2. Always carefully read the report letter to understand scope and base assumptions

## INTRODUCTION TO PETROLEUM SYSTEMS

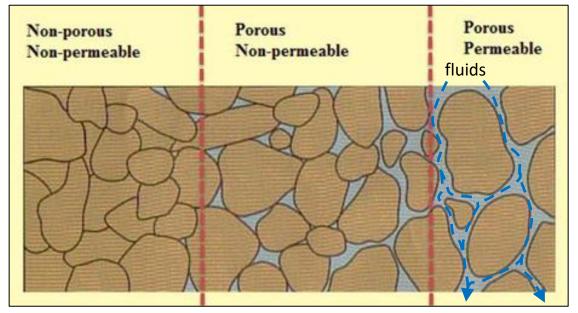


### What is a Reservoir Rock?

- A rock containing connected pore space (voids in rock) able to store and transmit fluids (water, oil, and gas)
  - Must have porosity (pore space) and permeability (connection between pore spaces)
  - The higher the porosity, the more storage capacity (more hydrocarbons in-place)
  - The higher the permeability, the easier it is to move hydrocarbons (higher production and recovery rates)



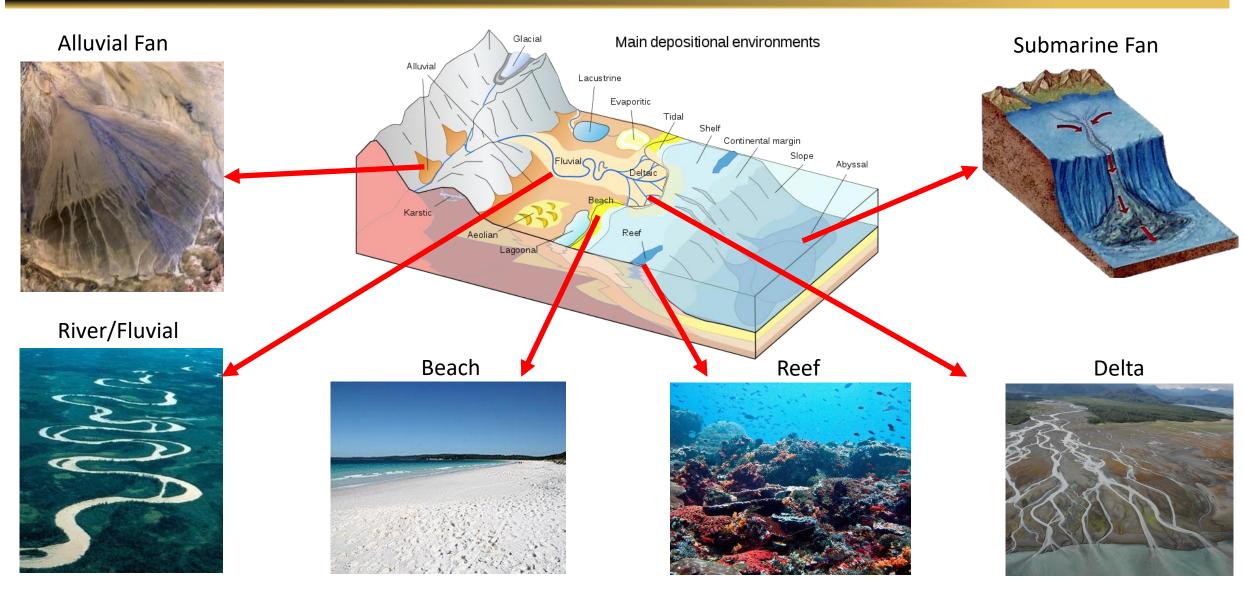




Soil Ecology Wiki



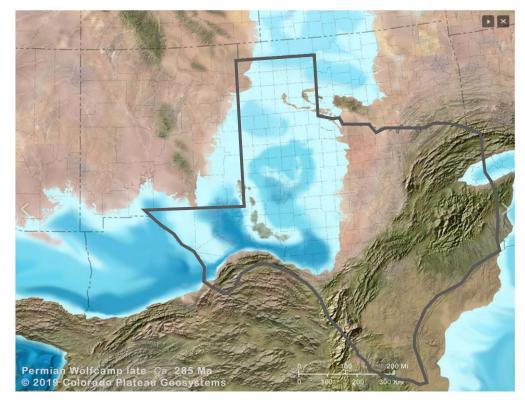
## What is a Sedimentary Basin?



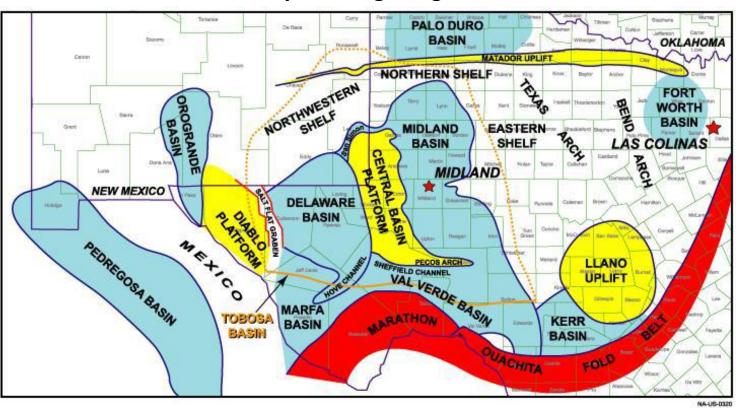


## **Example: Permian Basin**

#### Texas, 200 – 250 million years ago



#### Today's Geologic Regions...



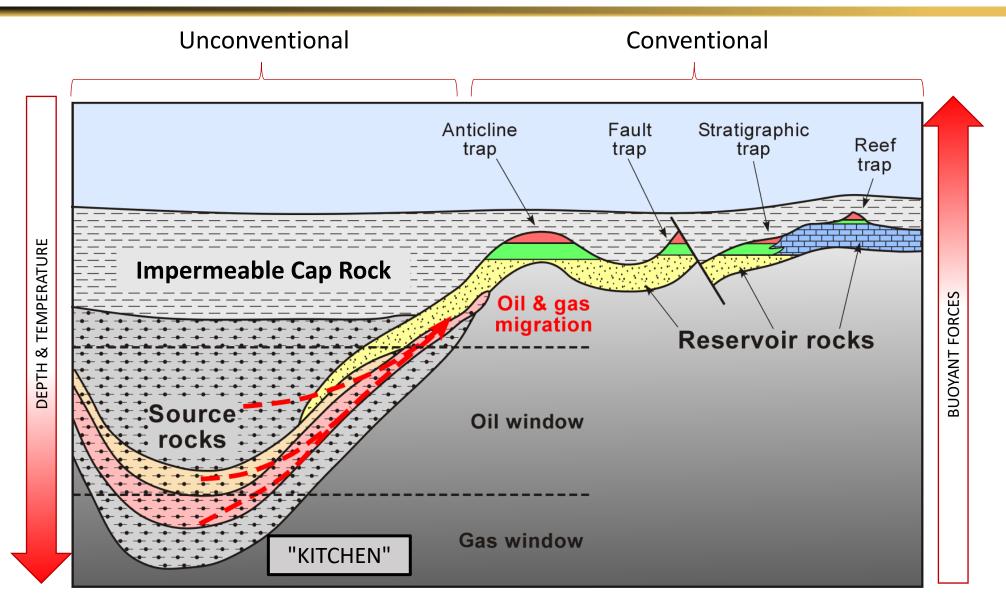
https://deeptimemaps.com/map-lists-thumbnails/greater-permian-basin/

Source: Pioneer Natural Resources, Investor Presentation – September 2014



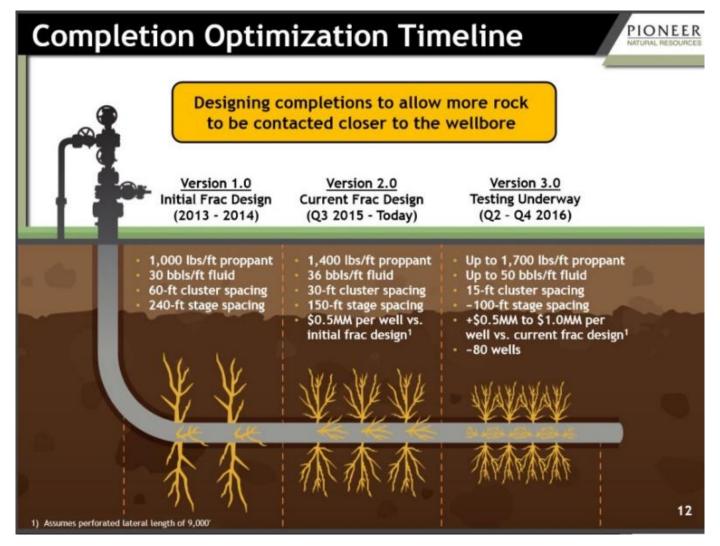


## **Types of Petroleum Reservoir**





## **Hydraulic Fracturing – Make Your Own Permeability**

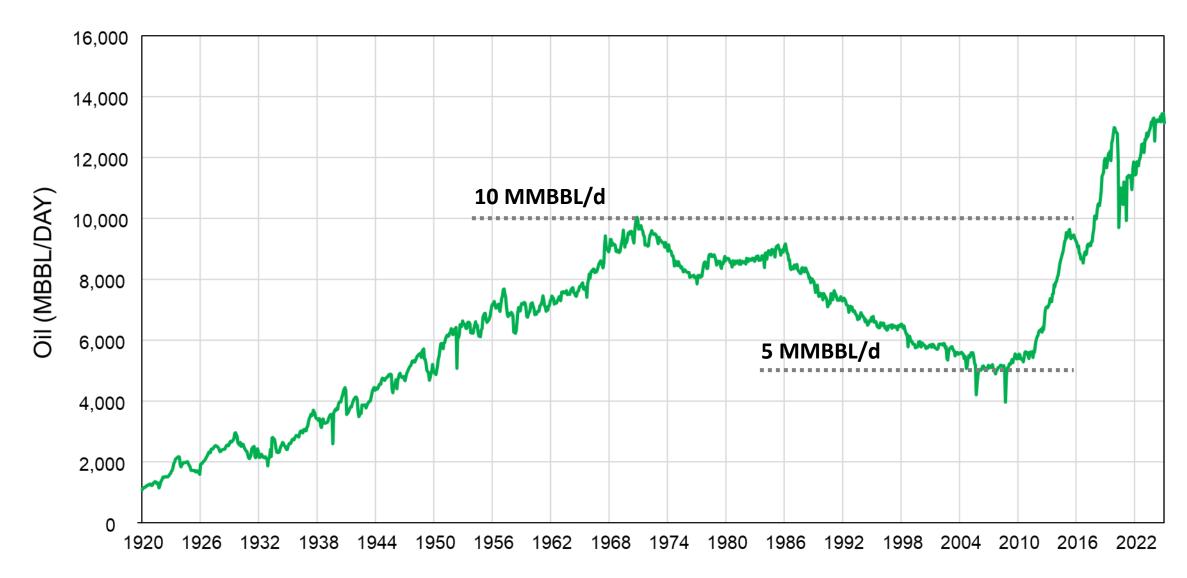


Source: Pioneer Natural Resources, Investor Presentation, March 2017



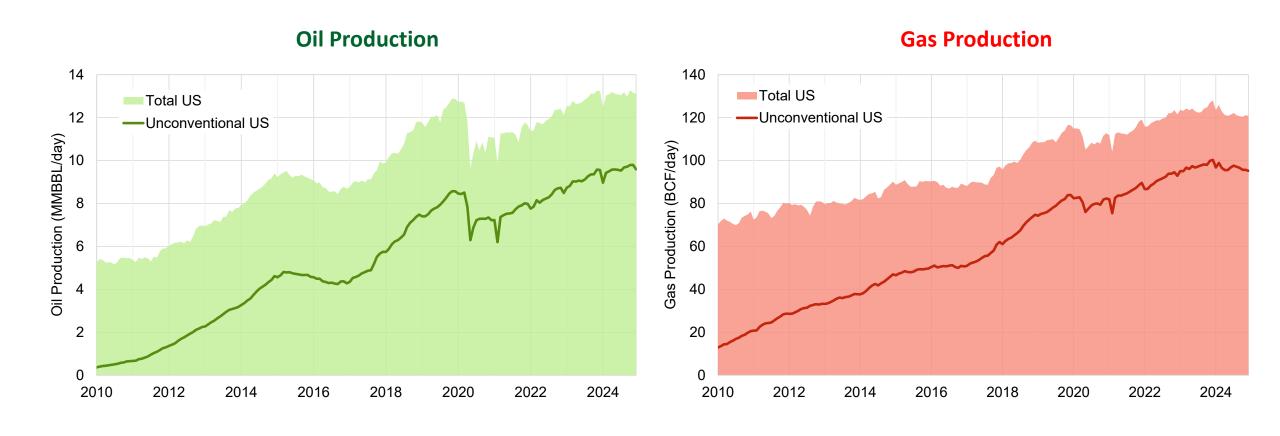


## **U.S. Crude Oil Production History**





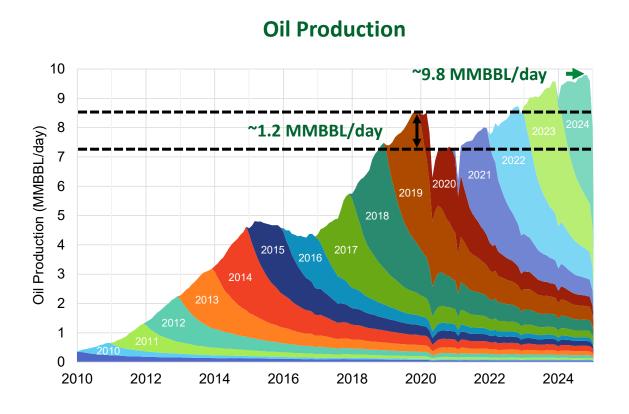
## **Unconventional Proportion of Production in the US**

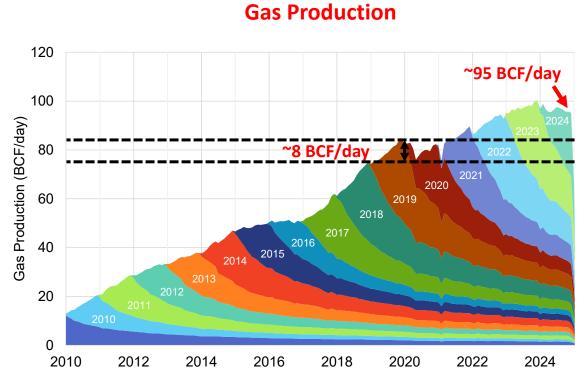






## **US Unconventional Production, by Vintage**

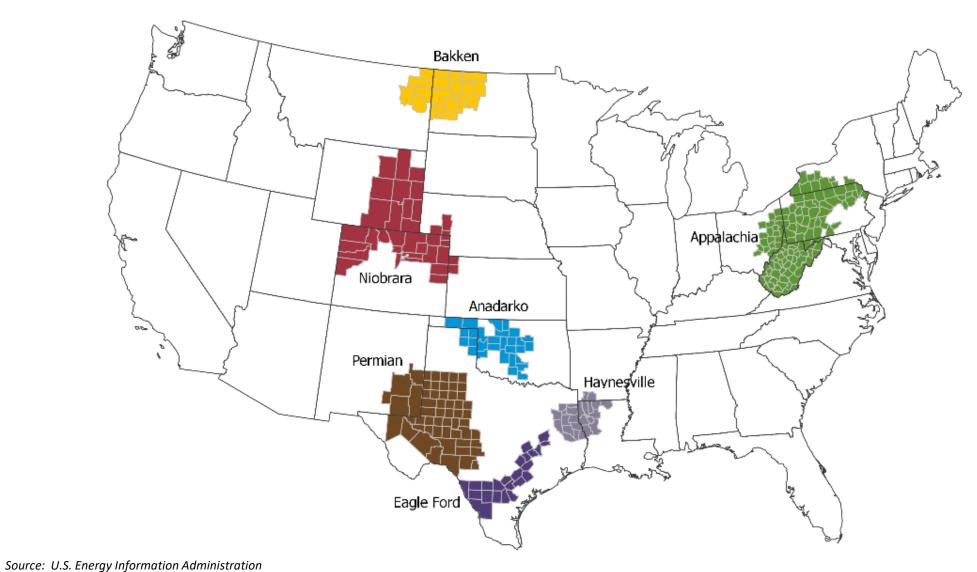








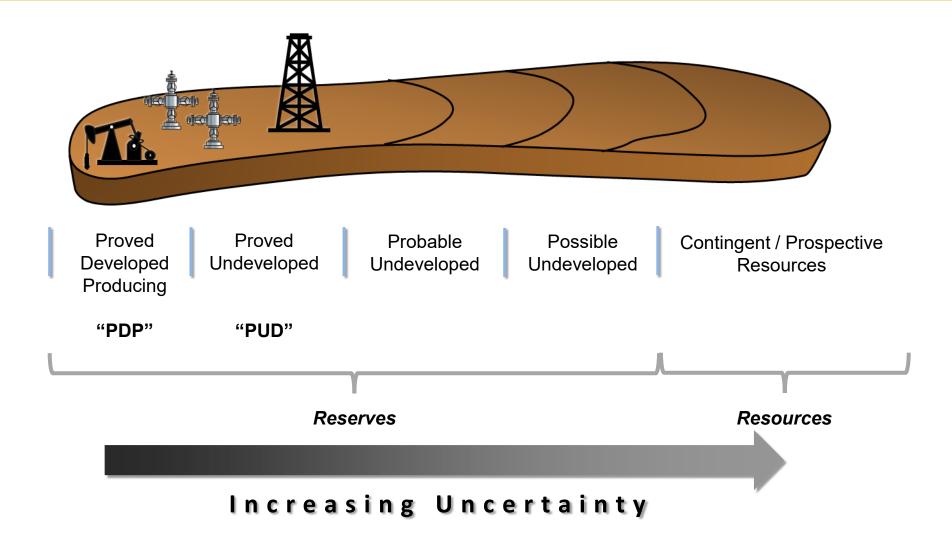
## **Key Unconventional Resource Areas**



## **RESERVES EVALUATION PROCESS**



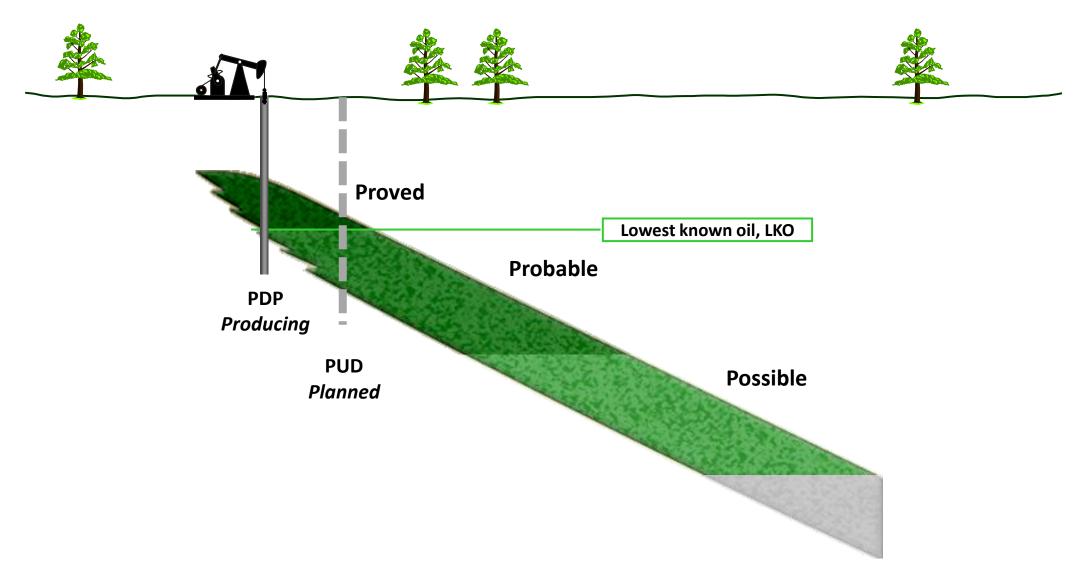
## **Reserves Categorization Concepts**





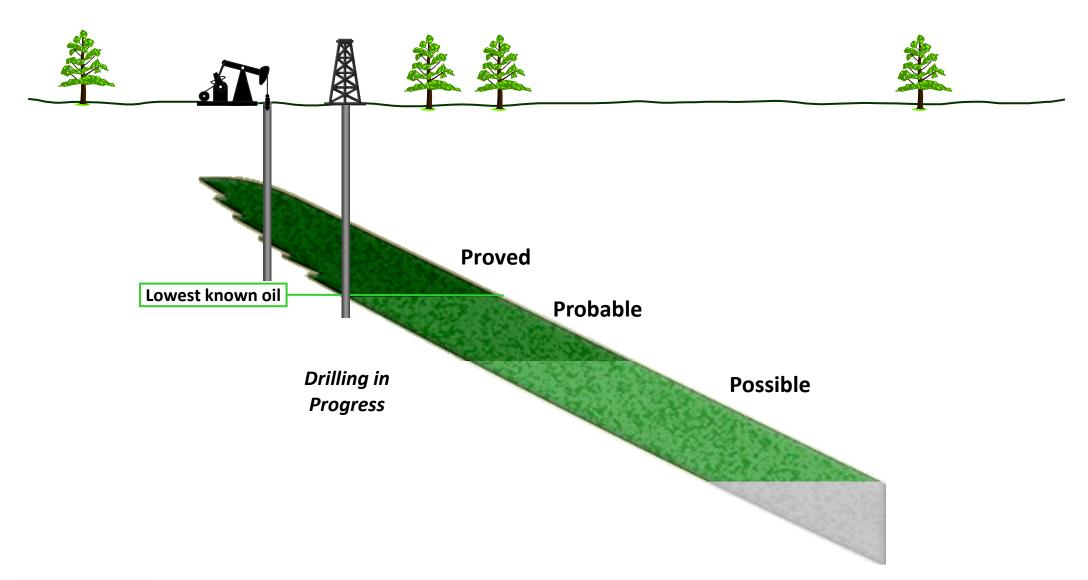


## **Reserves Categorization Example**



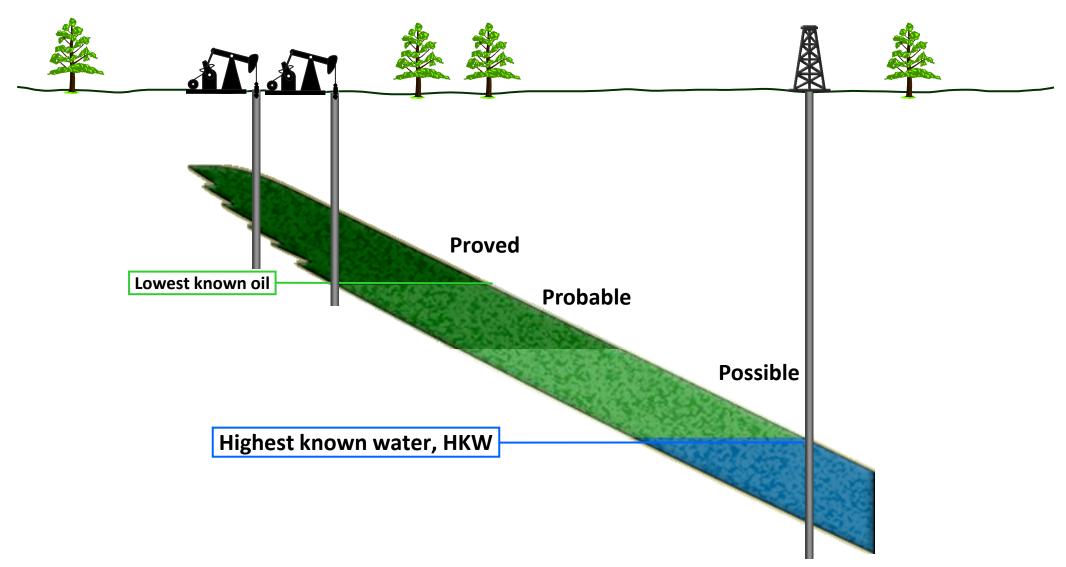


## **Reserves Categorization Example**



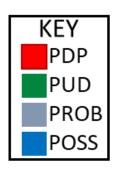


## **Reserves Categorization Example**

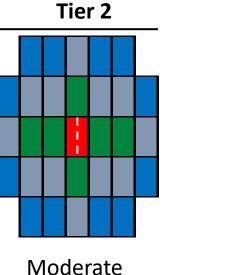


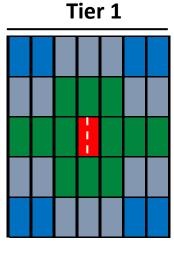


## **Unconventional Plays – Data Maturity**



Tier 3





- Property maturity
- 2. Data rich/poor
- 3. Consistency
- 4. Geologic understanding
- 5. Analogy to other areas
- 6. Economic robustness
- 7. Leverage effect (PUD/PDP)

Early Poor

?

Low

Low

Marginal

2.0

Good well control

Good

Still learning

Good

Strong (most wells)

?

Mature

Rich

Very good

High

Good

Very strong

5



## **Reserves Determination Methods**

**Probabilistic** - generates a range of estimates and their associated probabilities

- Quantitative/statistical risking
- Based on probability ranges of most significant variables
- In general, the utility and value of probabilistic methods decrease as uncertainty decreases
- Proved: 90% chance of reserves increasing over time

**Deterministic** - generates a discrete estimate of reserves for each reserves category

- Qualitative risking
- Based on relative certainty
- Proved: likelihood of achieving reserves is "reasonably certain"



## **Reserves Determination Methods**

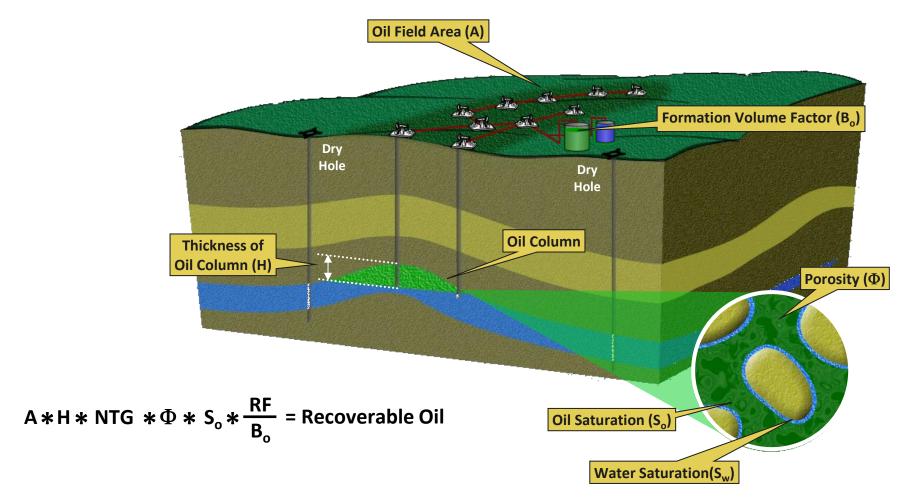
**Deterministic** Probabilistic Volumetrics **Performance Analysis Decline Curves** Material Balance Reservoir Simulation Analogy **Integrated Methods** 



$$\frac{\text{Recoverable}}{\text{Hydrocarbons}} = \left( \begin{array}{c} \text{Hydrocarbons-} \\ \text{in-Place} \end{array} \right) \times \left( \begin{array}{c} \text{Recovery} \\ \text{Factor} \end{array} \right)$$



## **Volumetric Equation**



NTG is the ratio of net pay to gross pay in the oil column. RF is recovery factor, or the percentage of in-place volume that is recoverable.





## **Decline Curve Analysis**

#### **Ideal Applications**

- Mature Properties
- Capacity Production (no artificial constraints)

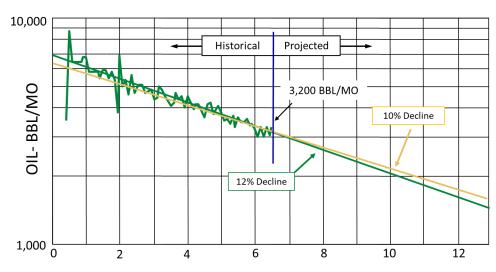
#### **Most Common Decline Types**

- Exponential
- Hyperbolic

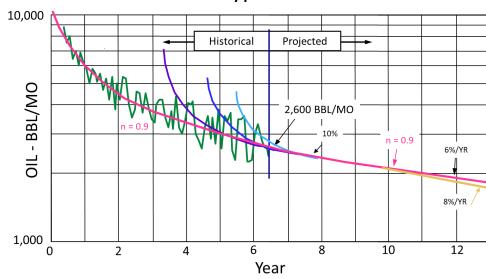
#### **Potential Pitfalls**

- Field level projection with significant activity levels
- Changing operational conditions
  - Lift capacity (GL, ESP, etc.)
  - Flowing tubing pressure

#### Exponential

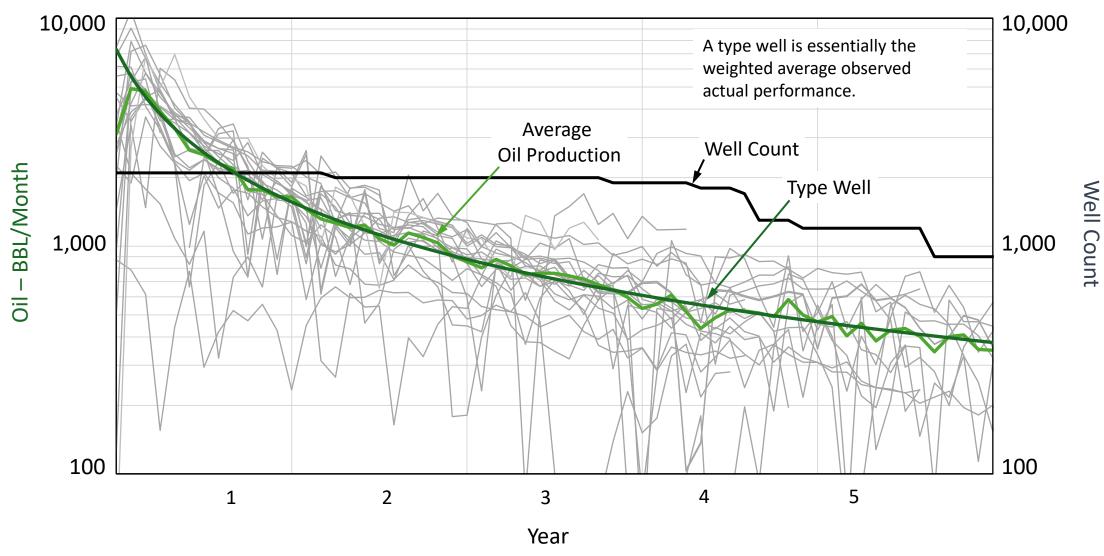


#### Hyperbolic



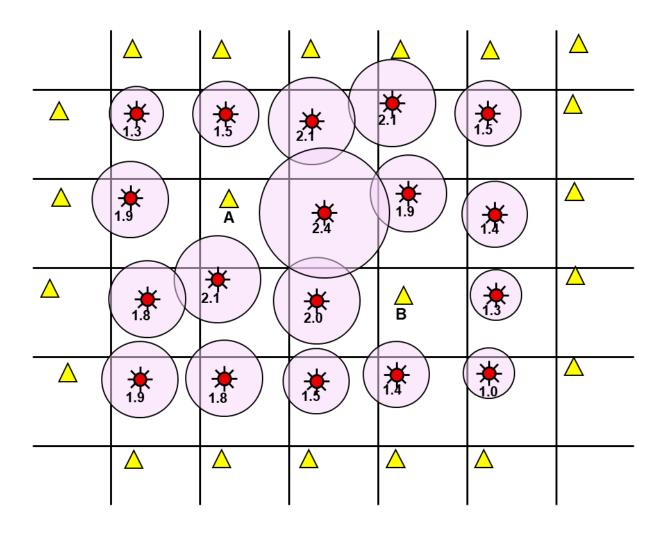


## Analogy – Type Well Analysis ("Type Curves")





## **Analogy – Offset Analysis (Statistical)**



#### **Ideal Applications:**

- Large fields with significant well count and production history
- Consistent geology, spacing, and well construction among PDP and PUD

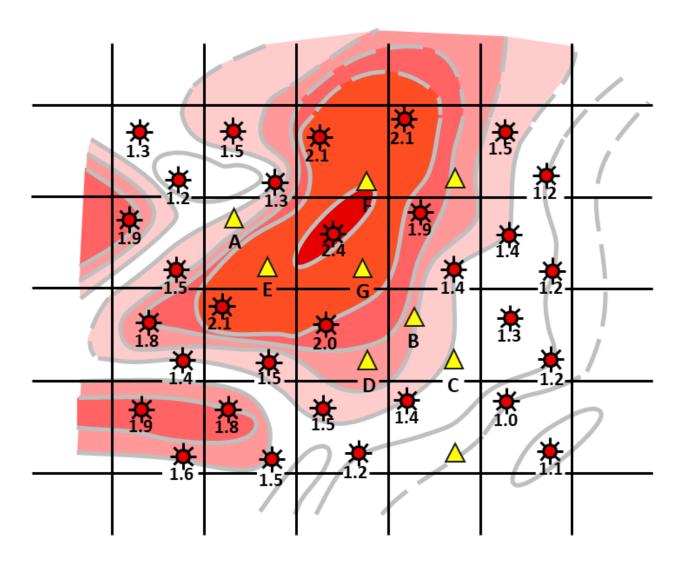








# **Analogy – Offset Analysis (Statistics + Geology)**



- Integrated analysis required if geologic characteristics change in field area
- Interference between new and old wells should be considered
- More sophisticated analysis, normalization, and extrapolation often required









# **ECONOMIC MODELING**

# By definition, reserves must be economic.

### Therefore:

- The economic model determines the volume of reserves.
- More importantly, the economic model determines the "value" of reserves.



## The Economic Model

## Incorporates estimates of:

- Oil and gas production forecasts
- Product price estimates
- Operating expense estimates
- Capital cost estimates

## Along with:

- Understanding of ownership
- Certain taxes
- Chosen price/cost escalation parameters



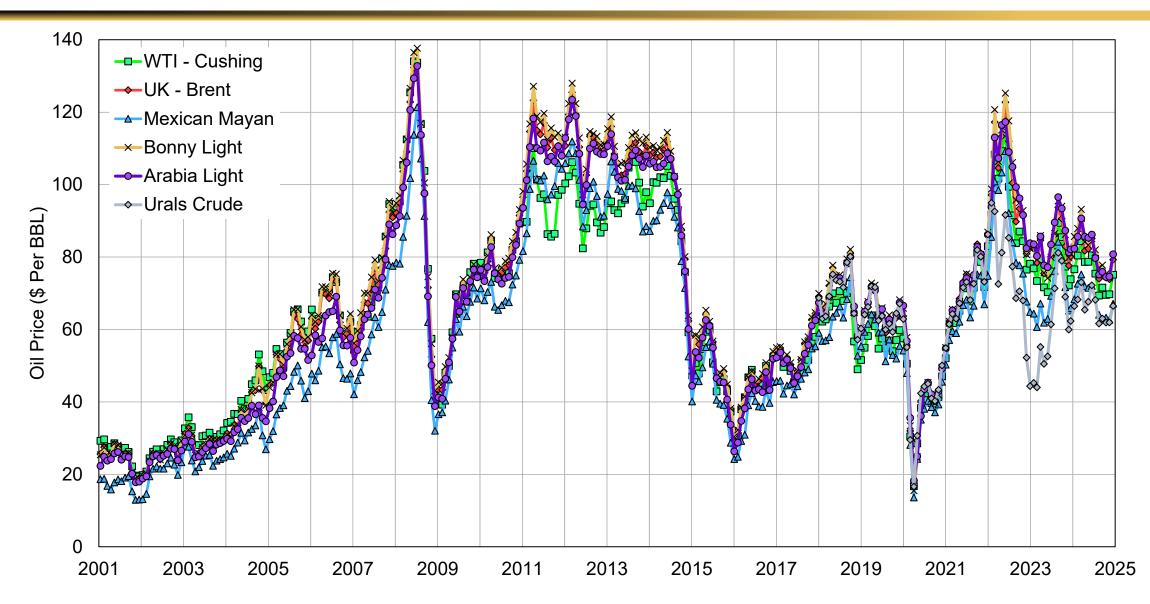


# **Important Pricing Terms**

- Benchmark Price: Reference price of oil or gas, chosen because it is both familiar in the industry and relevant to the properties being evaluated.
- Field Price or Realized Price: The price that is actually received for oil or gas sold from a given lease or field.
- **Price Differential**: The difference in price between an established benchmark and what is actually received at the lease or field. It can be positive or negative.



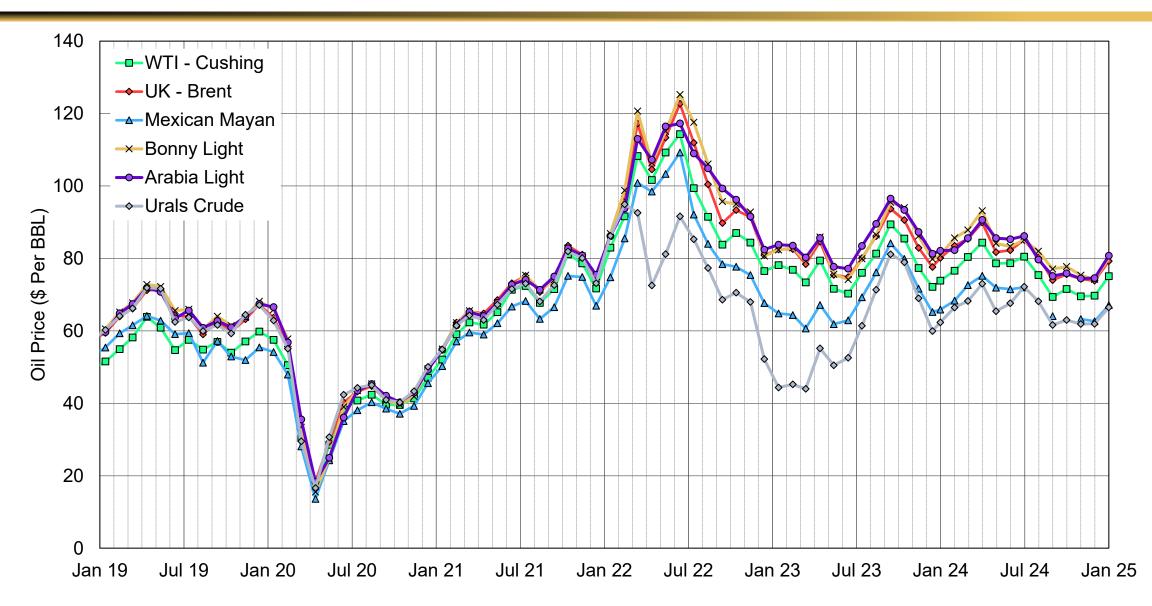
## **Worldwide Benchmark Crude Oil Prices**







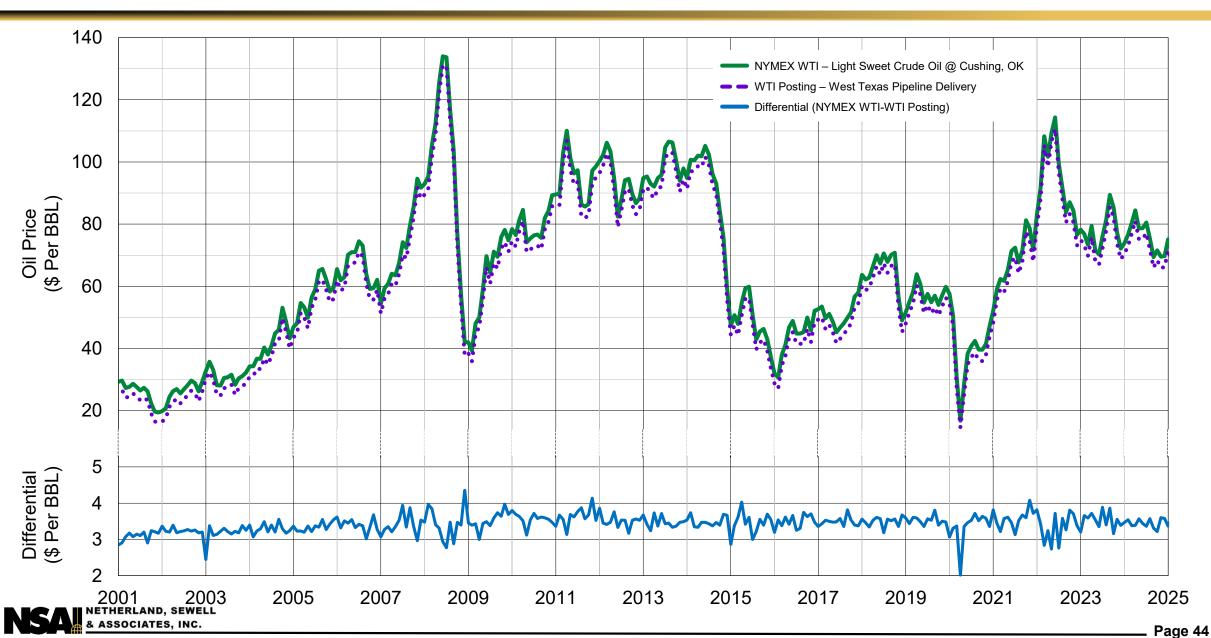
## **Worldwide Benchmark Crude Oil Prices**







## **Historical Benchmark Oil Prices**



# **Applying Ownership**

**Working Interest:** The share of total development and operating expenses that an individual or company must pay in return for their revenue interest share of total oil and gas production on a given lease.

**Revenue Interest:** The share of total oil and gas production to which an individual or company is entitled on a given lease.

Royalty Interest: A revenue interest only, with no working interest.

Ownership can be complicated by unitization, payout balances, profit sharing/net profits interests, sliding scale royalties, etc....



# **Applying Taxes**

## Taxes generally accounted for in a reserves report:

- Severance taxes
- Ad valorem taxes
- Special/supplemental petroleum taxes
- Value added taxes (VAT)

Taxes generally beyond the scope of a reserves report:

- State/provincial income taxes
- Federal/national income taxes





# **The Economic Calculation - Volumes**

Gross (100 Percent)
Oil and Gas Volumes
Produced

Less

Volumes Owned by Royalty Owners Volumes Owned by Other Working Interest Owners

Volumes Consumed in Lease Operations

+

### **Equals**

Net Produced
Oil and Gas Volumes
Available for Sale

Then oil and gas prices are applied...



# **The Economic Calculation - Net Revenues**

Oil and Gas Revenues to Net Interest

#### Less

Direct
Operating + Overhead or COPAS Charges

Expenses

Overhead or COPAS Charges

Taxes

Production and Capital

Ad Valorem + Expenditures

Taxes

(as spent)

### **Equals**

Net Revenue Before Federal Income Taxes



# **Evaluation from Client Perspective**

#### Data to be provided to engineer:

- Listing of properties by well (i.e. API) and decimal interest
- History of lease operating or revenue statements, ideally 12 months prior
- Development plans including drilling locations and capital requirements
- Acreage maps, if available

#### **Typical work products provided to client:**

- Reserves Report including letter, cash flow forecast, and summary results by well
- Reserves database (e.g. ARIES, PHDWin)
- Wide range of potential sensitivities and outputs possible from completed model

#### Disclaimer

This presentation is for general information and illustrative purposes only—its contents should be considered in context of the entire presentation and the date on which it is presented. All estimates, exhibits, and opinions presented herein are subject to change. As in all aspects of oil and gas evaluation, there are uncertainties inherent in the interpretation of engineering and geoscience data; therefore, our opinions necessarily represent only informed professional judgment. We make no representations or warranties of any kind, express or implied, about the completeness, accuracy, reliability, or suitability of the information contained herein; we will not be responsible for any consequence associated with the reliance on such information. Unless indicated otherwise, the information contained herein does not constitute professional advice or opinions, and it should be considered to be a work in progress. Netherland, Sewell & Associates, Inc. (NSAI) is a Texas Registered Engineering Firm, No. F-2699.

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