

# **A PERSPECTIVE ON PETROLEUM RESERVES AND EVALUATION ISSUES**

**Presented to Gerson Lehrman Group  
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# DISCUSSION MATERIAL

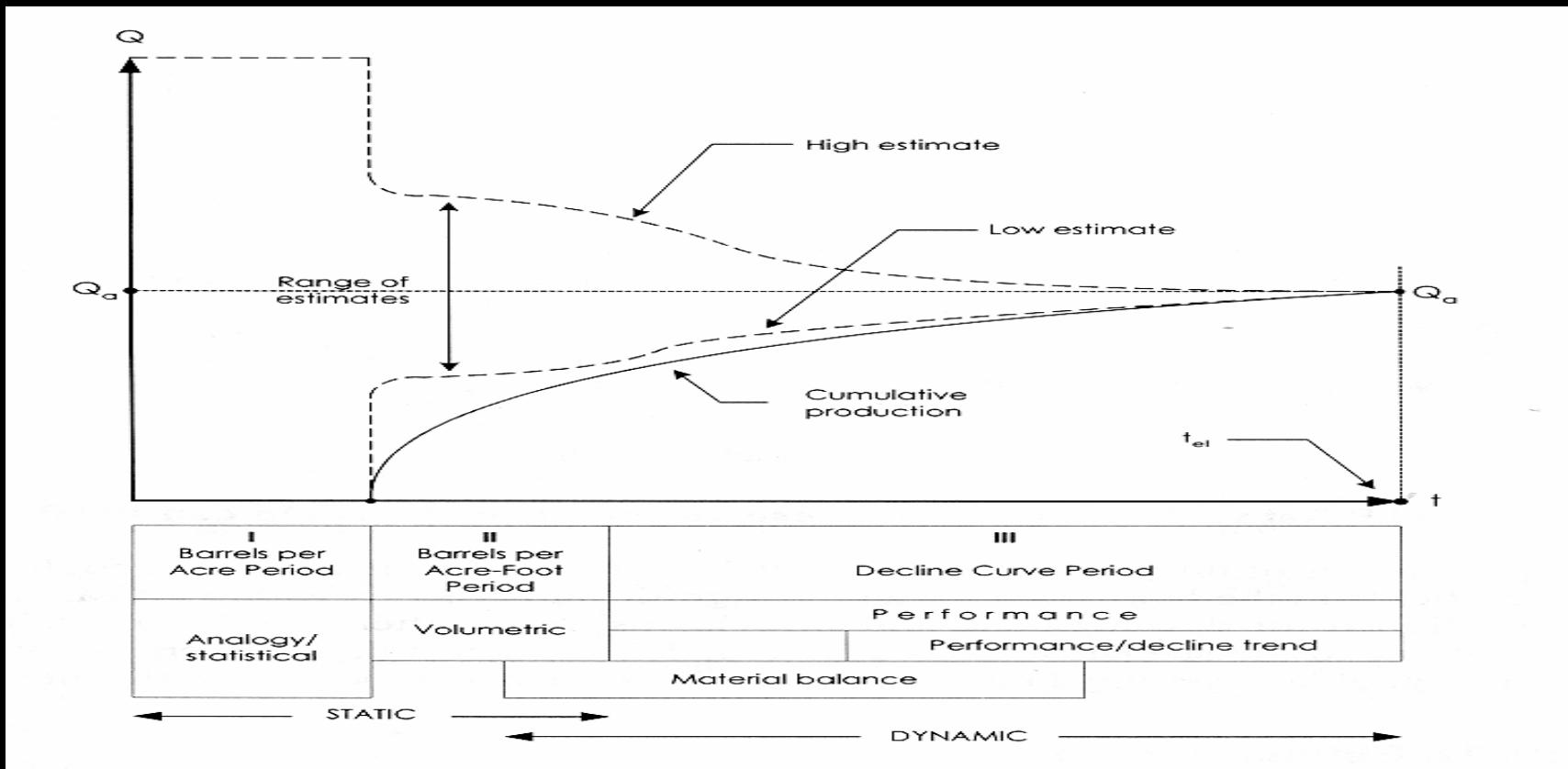
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- Reserve Evaluation Fundamentals
- History of Reserve Definitions
- Proved, Probable and Possible Reserves
- SEC Hot Button Issues
- Reports, Audits and Reviews



# Maturity of Asset



Original Source: Arps, J.J.: Estimation of primary oil reserves, Trans., AIME, 1956  
 Additional Annotation by: Cronquist, C.: Estimation and Classification of Reserves of Crude oil, Natural Gas, and Condensate", SPE 2001



# RELEVANT TERMS

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- **Reserves**

- **Resources**

  - Contingent**

  - Undiscovered**



# RESERVES

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## Reserves

**are remaining quantities of hydrocarbons  
to be commercially produced  
from a known accumulation  
as of a given date  
under stated definitions  
and economic conditions.**



# ESTIMATION OF RESERVES - 1

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## Volumetric method

Maps are created using well and seismic data

- Structure maps describing “topography of the surface of the reservoir rock
- Isopachous (equal thickness) maps drawn to define the reservoir
- Gross volume of reservoir (acre-feet) reduced to net volume of oil (or gas) using calculated porosity (logs/cores) and saturations
- Recovery factor applied to gross hydrocarbons in place to obtain initial reserves
- Cumulative production deducted (at date of report) to estimate reserves



# ESTIMATION OF RESERVES - 2

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## Performance methods

Once a well or reservoir has begun producing, careful records are maintained to record daily and monthly production rates of oil, gas and water along with well-head and reservoir pressure data.

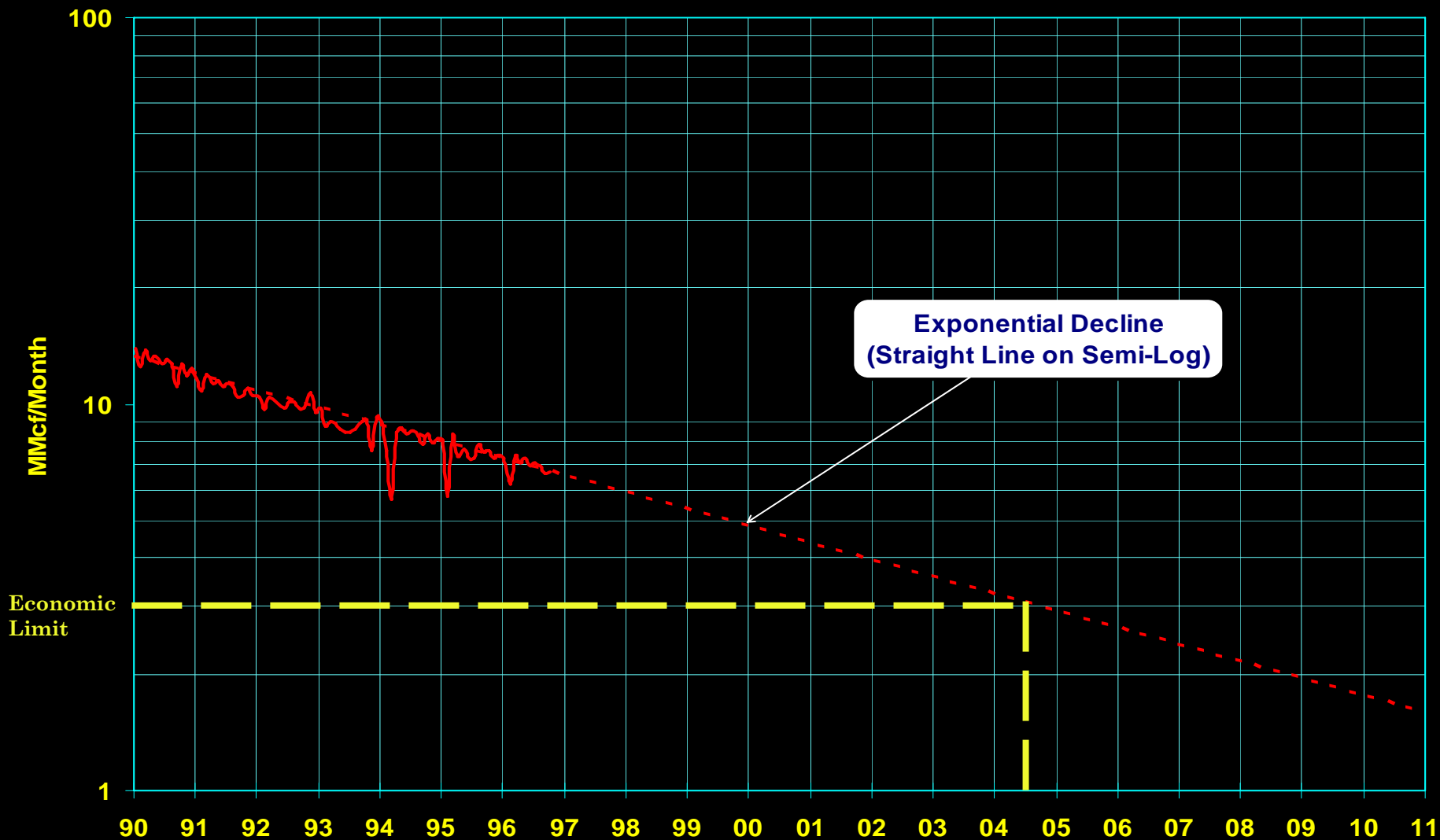
These data can then be used in various forms of graphical projections as both pressures and production rates typically decline over time.

- Monthly production vs time
- Monthly production vs cumulative production
- Reservoir pressure vs cumulative production (gas)
- Produced oil/water ratios vs time
- And many other trend relationships

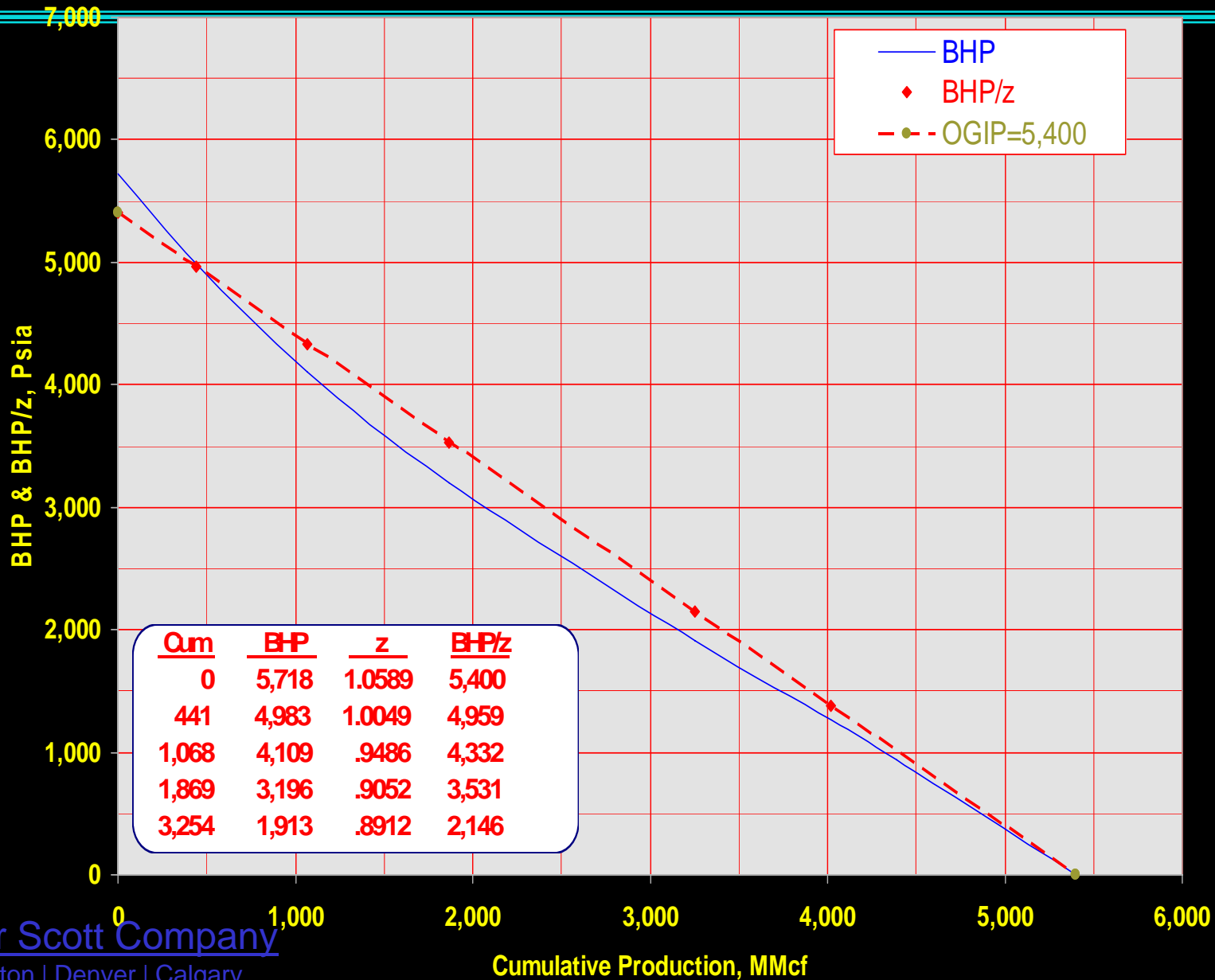
All of these projections must take economics into effect to determine the remaining economic life of the well/reservoir.



# Typical Depletion Drive Gas Well Decline



# Depletion Drive Gas Well Material Balance



# HISTORY OF RESERVES DEFINITIONS - 1

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- (1936)

API created early oil reserves definitions and began use of the term “proved reserves”.

- (1946)

AGA created definitions for natural gas and joined API in annual reserves reports for U.S.



# HISTORY OF RESERVES DEFINITIONS - 2

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- (1946 -1979)

API-AGA published annual reports of proved reserves of oil, gas and ngl for U.S.

- (1964)

Society of Petroleum Engineers (SPE) adopted proved reserves definitions similar to API.



# HISTORY OF RESERVES DEFINITIONS - 3

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- (1978)

U.S. SEC issued definitions for proved reserves.

- (1981)

SPE issued revised definitions for proved reserves.



# HISTORY OF RESERVES DEFINITIONS - 4

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- (1983)

World Petroleum Congresses issued expanded definitions for reserves and resources.

- (1987)

SPE published definitions for proved, probable and possible categories of reserves.

WPC published (independent) definitions similar to SPE.



# HISTORY OF RESERVES DEFINITIONS - 5

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- (1997)

**SPE/WPC jointly adopted definitions for proved, probable and possible reserves and deterministic and probabilistic methodologies.**

- (2000)

**SPE/WPC/AAPG (American Association of Petroleum Geologists) approved petroleum resource definitions.**



# TERMS USED TO DESCRIBE PROVED RESERVES

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- (1946) API-AGA  
“Every reasonable probability”
- (1960) API-AGA  
“Beyond reasonable doubt”  
“Virtually certain”
- (1964) API-AGA/SPE  
“Reasonable certainty”



# *SEC Guidelines*

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## *“Reasonable Certainty”*

- “The concept of reasonable certainty implies that, as more technical data becomes available, a positive, or upward, revision is much more likely than a negative, or downward, revision.”

# *SEC Guidelines*

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## *Reasonable Certainty Requirements*

- Generated by supporting geological and engineering data.
- Validation of assumptions are necessary.
- Criteria for analogies should be equal to or better than referenced reservoirs used as analogies.
- Reasonable certainty is more than just the technical considerations that oil and gas is recoverable. It also includes resolution of how other barriers such as financial, environmental, marketing, legal and political will be overcome.



# DETERMINISTIC

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**A single best estimate of reserves**

**is made**

**based on known**

**geological,**

**engineering**

**and**

**economic data.**



# PROBABILISTIC

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**The known  
geological, engineering and economic data  
are used  
to generate a range of estimates  
and  
their associated probabilities.**



# PROVED RESERVES

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- **Deterministic - Reasonable Certainty**
- **Probabilistic - 90% Certainty**
- \*Both may need to be adapted to meet regulatory standards**

# DETERMINISTIC APPROACH

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## Category

## Descriptive Term

Proved (P1)

Reasonable certainty

Probable (P2)

More likely than not

Possible (P3)

Less likely than probable

# PROBABLISTIC APPROACH

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## Category

## Descriptive Term

**Proved (1P)**

**At least 90 % probability**

**Proved + Probable (2P)**

**At least 50 % probability**

**Proved + Probable + Possible (3P)**

**At least 10 % probability**



# RESERVE CLASSIFICATION

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**Proved**

**Developed**

**Producing**

**Non-Producing**

**Shut-in**

**Behind Pipe**

**Undeveloped**



# RESERVE DEFINITIONS - PROVED

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## SEC 1978

- Proved oil and gas reserves are the estimated quantities of crude oil, natural gas, and natural gas liquids which geological and engineering data demonstrate with *reasonable certainty* to be recoverable in future years from known reservoirs under existing economic and operating conditions, i.e., prices and cost as of the date the estimate is made.

## SPE/WPC 1997

- Proved reserves are those quantities of petroleum which, by analysis of geological and engineering data, can be estimated with *reasonable certainty* to be commercially recoverable, from a given date forward, from known reservoirs and under economic condition, operating methods, and government regulations.



# BACKGROUND AND HISTORY OF SEC OIL & GAS RESERVES DEFINITIONS

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- **SEC definitions static since 1978. A time of...**
  - Relatively Stable Prices**
  - Long Term Gas Contracts**
  - U.S. Domestic Mindset**
- **Industry Trends Since 1978...**
  - Changing reservoir evaluation technology many advancements – reduced uncertainty**
  - More widespread use of production sharing contracts**
  - More use of probabilistic assessments**



# SEC STAFF

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- **Petroleum engineering vacancy most of 1990s**
- **Geologist added for short time in mid-1998**
- **Two engineers joined in early 1999**
  - **Ron Winfrey – Physics grad from OU –ex Ramsay Engineering**
  - **Jim Murphy – PE grad UH – ex ARCO, J.R. Butler cons. – DOE**
- **Assistant director of the Office of Corporate Finance, Natural Resources Group, is Roger Schwall**



# RESERVE DEFINITION - PROBABLE

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## SPE/WPC 1997

- Probable reserves are those unproved reserves which analysis of geological and engineering data suggests are more likely than not to be recoverable. In this context, when probabilistic methods are used, there should be at least a 50 percent probability that the quantities actually recovered will equal or exceed the sum of estimated proved plus probable reserves.



# RESERVE DEFINITION - PROBABLE

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- Reserves anticipated to be proved by normal step-out drilling where sub-surface control is inadequate to classify as proved.
- Reserves in formations that appear productive from well logs but lack cores or definitive tests and are not analogous to proved reserves in the area.
- Incremental reserves attributable to infill drilling that lack closer statutory spacing.
- Reserves attributable to improved recovery methods that are proved as commercially successful but a pilot is not in place.
- Reserves in an area of the formation that is fault separated from the proved area and the area is structurally high to the proved area.
- Reserves from a workover, treatment, change of equipment or other mechanical procedures not yet proved successful.
- Incremental reserves in proved reservoirs where an alternative interpretation indicates more reserves than classified as proved.



# RESERVE DEFINITION - POSSIBLE

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## SPE/WPC 1997

- Possible reserves are those unproved reserves which analysis of geological and engineering data suggests are less likely to be recoverable than probable reserves. In this context, when probabilistic methods are used, there should be at least a 10 percent probability that the quantities actually recovered will equal or exceed the sum of estimated proved plus probable plus possible reserves.



# RESERVE DEFINITION - POSSIBLE

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- Reserves which, based on geological interpretations, could possibly exist beyond areas classified as probable.
- Reserves in formations that appear hydrocarbon bearing based on logs and cores but may not produce at commercial rates.
- Incremental reserves attributed to infill drilling that are subject to technical uncertainty.
- Reserves attributed to improved recovery methods when a pilot or project is planned but not in operation and rock, fluid and reservoir characteristics are such that reasonable doubt exists as to the projects commerciality.
- Reserves in an area of the formation that appears fault separated from the proved area and is structurally lower than the proved area.



# SEC Red Flags and Hot Button Topics

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- **Technical Issues**
  - Validation of proved undeveloped locations (PUDS)
  - Proper use of analogies
  - Determination of down dip limits/LKH
  - Application of seismic interpretations
  - Recovery factors
  - Application of reservoir simulation
  - Flow testing/Data comprising a conclusive formation test
- **Commercial Issues**
  - SEC year-end pricing
  - Costs – Capex and Opex
  - Non-hydrocarbon revenues
  - Financial commitment to develop/project stagnation
  - Project sanctioning
  - Commerciality – lack of market
  - Booking under PSC'S



# SEC HOT-BUTTON TOPICS

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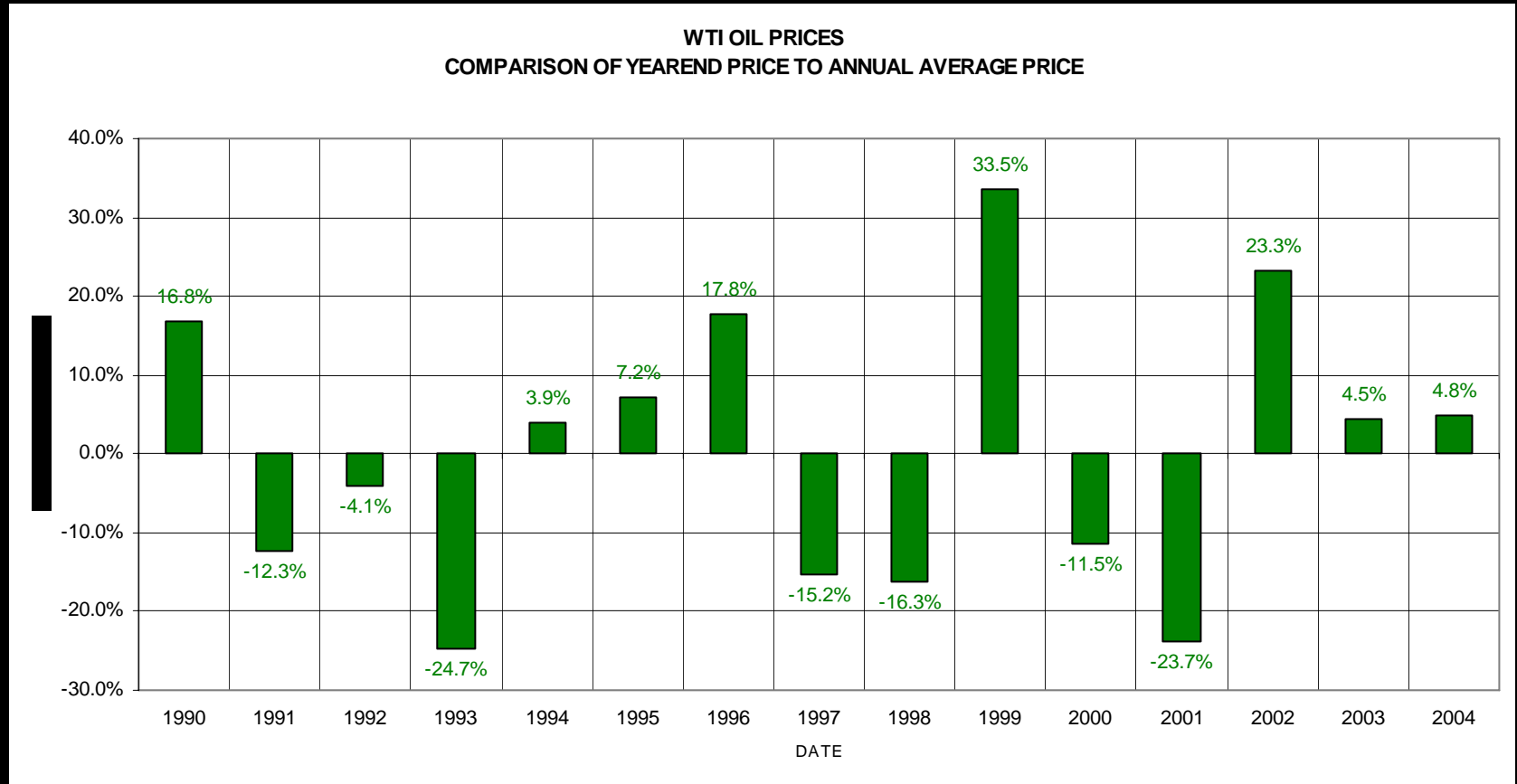
## A) SEC year-end pricing

- SPE/WPC – allow some latitude, average period OK
- SEC – no interpretation. Must use price on effective date
  - SEC position reflects its dated origins (1978)
    - A time with less volatility in O&G markets
    - Now O&G sold on spot markets
  - Year-end price to be used for rev. projections and economic limits
    - Can lead to abnormally high (or low) economic well lives



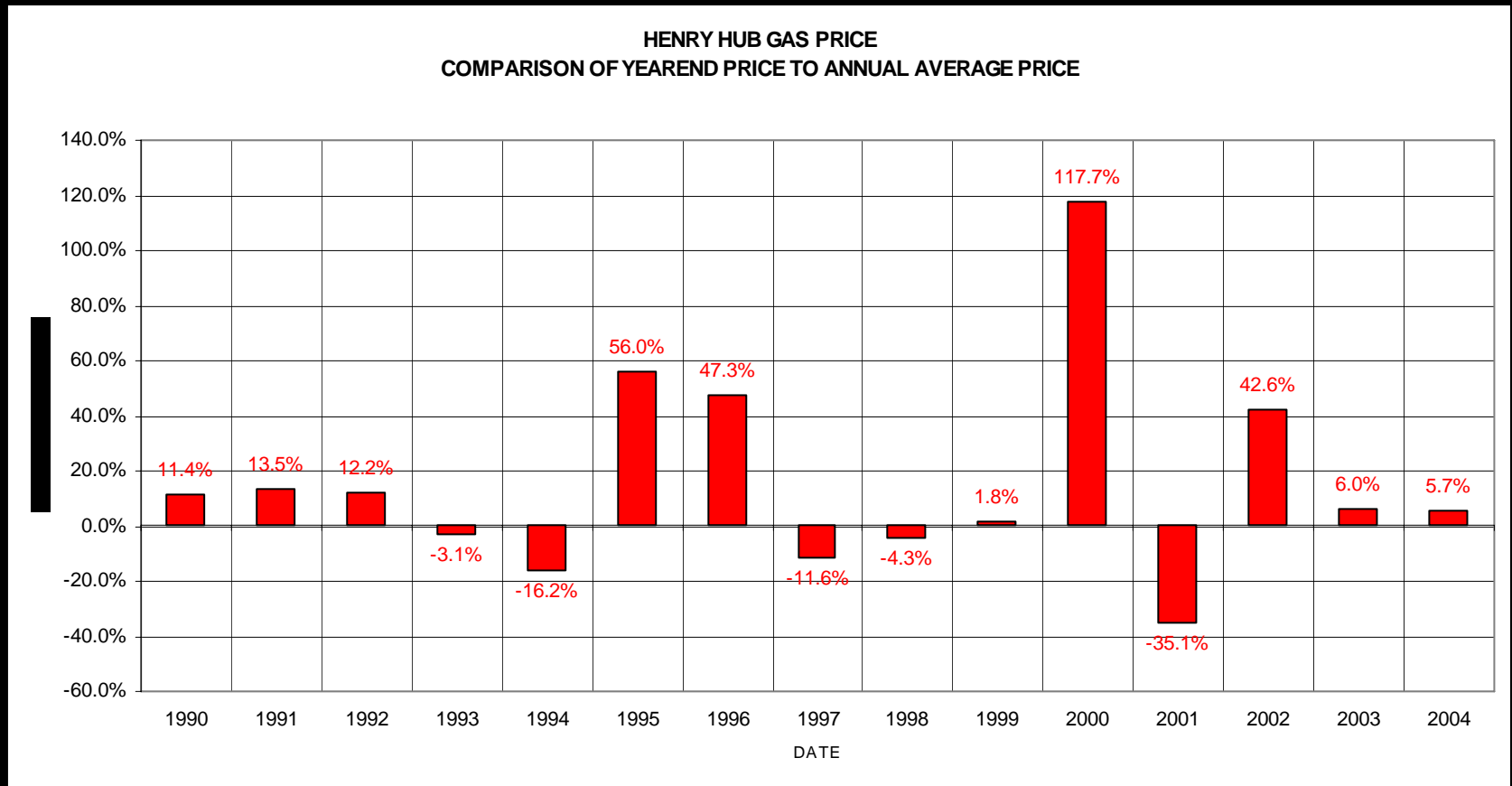
# CONSEQUENCES OF SEC SINGLE DAY YEAR-END PRICE

## A) SEC Year-End Pricing



# CONSEQUENCES OF SEC SINGLE DAY YEAR-END PRICE

## A) SEC Year-End Pricing



# SEC HOT-BUTTON TOPICS

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## B) Recovery factors

- SEC increasing scrutiny
- Staff pressing for hard evidence for recovery factor's higher than low-side of range
- May ask for supporting documentation of assumptions
  - Examples:
    - water drive for oil
    - absence of water drive for gas



# SEC HOT-BUTTON TOPICS

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## C) PUD's

- One offset “rule” (regulatory spacing)
- Website – “certainty” beyond one location
- Rule also applies to CBM

# SEC HOT-BUTTON TOPICS

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## **D) Reliance upon seismic interpretations**

- **Historically SEC has dismissed as too uncertain for proved reserves**
- **Extension of lowest known hydrocarbons**
- **Proving up nearby untested analog structures**



# SEC HOT-BUTTON TOPICS

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## **E) Booking reserves under PSC's**

### **– Necessary Elements**

- Right to develop and extract**
- Reasonable certainty of production**
- Intent and commitment to develop**
- Capital at risk**
- Legal right to produce at the date of the estimate**
  - SEC Position – after foreign government declaration of commerciality or government approval of development plan**
  - Exceptions if “Compelling Case” made to SEC**



# SEC HOT-BUTTON TOPICS

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## **F) Determination of LKH – SEC - well logs only**

- SEC position can lead to significant differences relative to SPE/WPC reserves
- Reversal of 2000 SPEE forum position – “compelling case”



# SIGNIFICANT DIFFERENCES IN SEC AND SPE / WPC RESERVES DEFINITIONS

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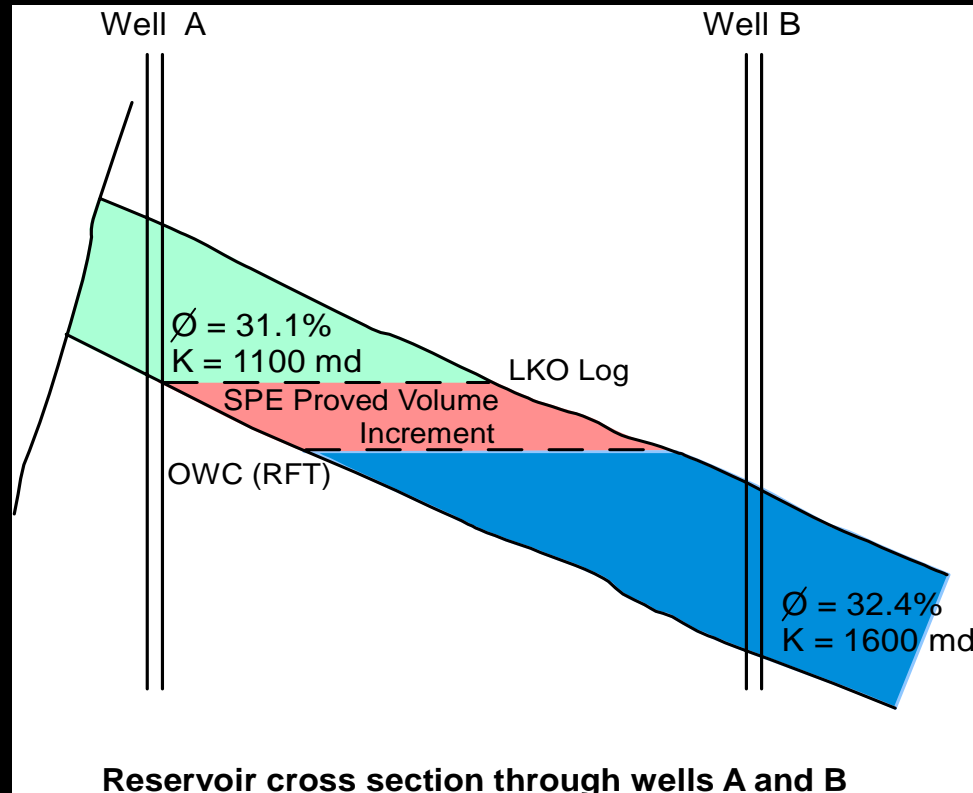
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- **Determination of lowest-known hydrocarbons**
  - SPE and SEC definitions read similarly
    - SEC – *“in the absence of information on fluid contacts, the lowest known structural occurrence of hydrocarbons control the lower proved limit of the reservoir.”*
    - SPE – *“lowest known occurrence of hydrocarbons controls the proved limit unless otherwise indicated by definitive geological, engineering or performance data.”*



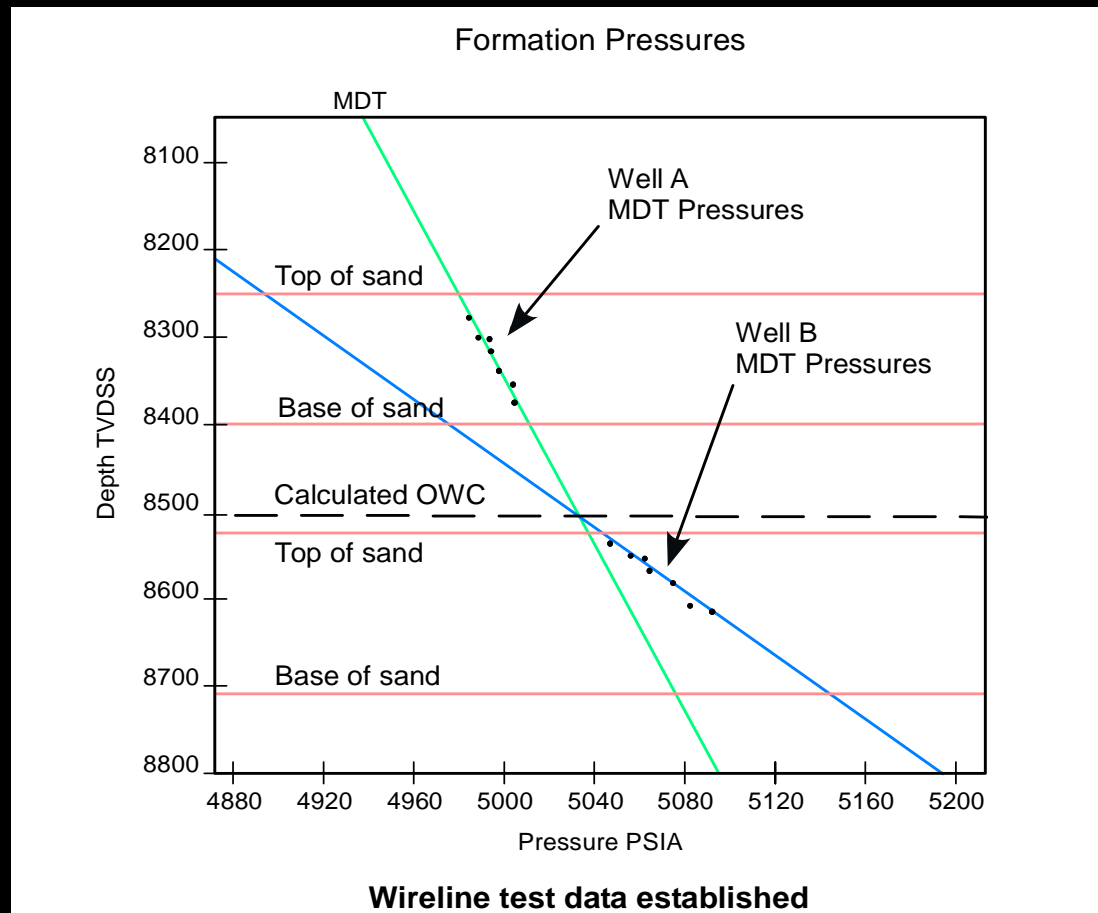
# SIGNIFICANT DIFFERENCES IN SEC AND SPE / WPC RESERVES DEFINITIONS

- Determination of Lowest-Known Hydrocarbons



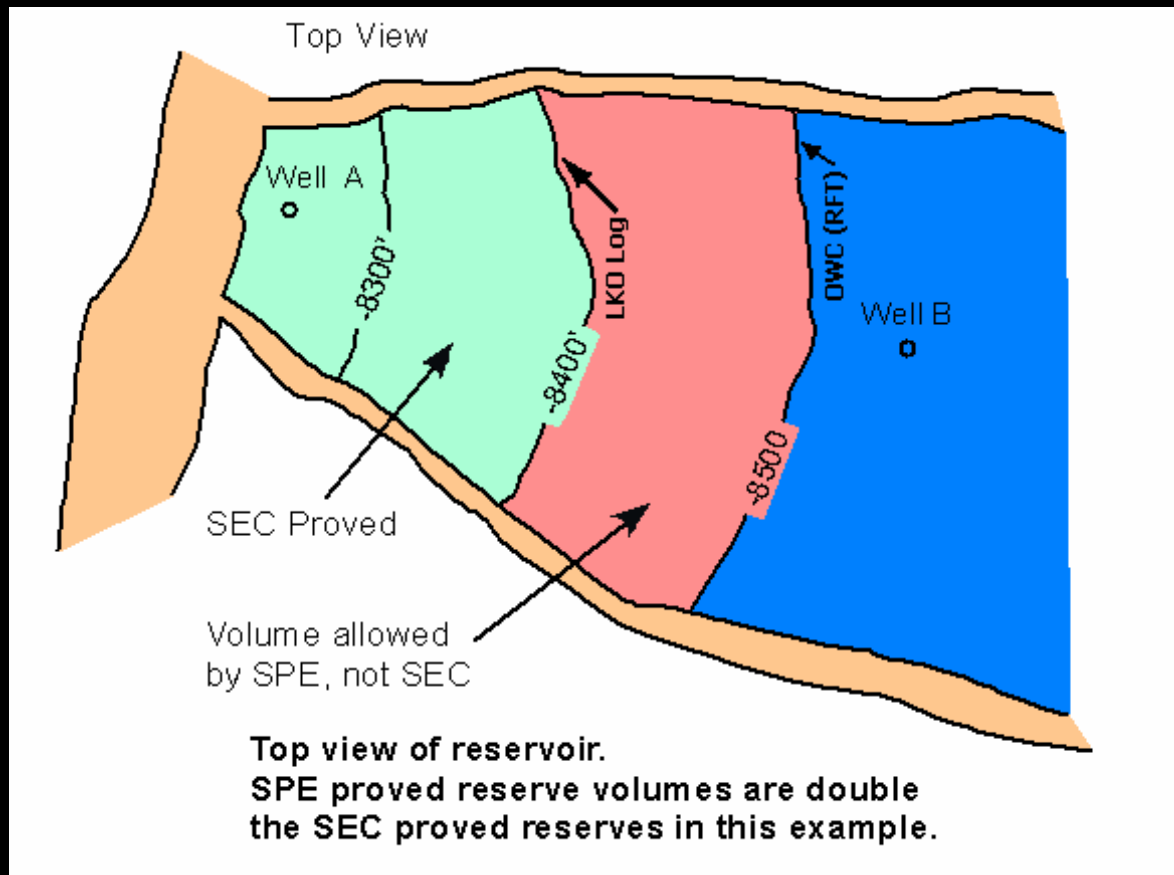
# SIGNIFICANT DIFFERENCES IN SEC AND SPE / WPC RESERVES DEFINITIONS

- **Determination of Lowest-Known Hydrocarbons**



# SIGNIFICANT DIFFERENCES IN SEC AND SPE / WPC RESERVES DEFINITIONS

- Determination of Lowest-Known Hydrocarbons



# SEC HOT-BUTTON TOPICS

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## G) Simulation-derived reserves estimates

- Model in-place volumes limited by SEC
  - LKH limitations
  - Flow test requirements
- SEC recognizes models often represent expected case
- SEC requires “good history match”



# SEC HOT-BUTTON TOPICS

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## H) Revenue from Sale of Non-Hydrocarbons

- SEC Prohibits All Non-Hydrocarbon Reserves (including Sulphur , CO<sub>2</sub> , and Helium)
- Third Party Processing Revenue excluded
- Cannot use non-hydrocarbon income to offset or reduce operating costs



# SEC HOT-BUTTON TOPICS

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## I) Flow Test Requirements

- SEC – *“Reserves are considered proved if economic producibility is supported by either actual production or conclusive formation test.”*
- Recent SEC Survey on Booking Practices in GOM
  - SEC “Special Project”
  - Inquiry concerning booking proved reserves without conventional flow test
  - Addressed in 2002 SPEE Forum with SEC



# SEC HOT-BUTTON TOPICS

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## I) Flow Test Requirements

- **Significant Unresolved Issue – SEC Definition of “*conclusive formation test*” - GOM**
  - **In certain areas – not seen as necessary or feasible**
  - **Producers reasons for no flow test in deepwater GOM**
    - **Redundancy to calculated test rates**
    - **Costs often exceed \$10MM**
    - **Delays of up to two years**
    - **Environmental concerns and permitting requirements**



# SEC HOT-BUTTON TOPICS

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## I) Flow Test Requirements

- **Potential Impact of Pending SEC Decision – If Position Enforced**
  - **Producers will be required to under report reserves**
  - **Impact will be greater on smaller independents**
  - **SEC's mandate of full disclosure may not be met**



# SEC HOT-BUTTON TOPICS

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## **J) Net Profits Interest (NPI)**

- For properties subject to payment of net profits, SEC requires property owner to deduct NPI “reserves” from owned reserves**
- SPE/WPC definitions – silent, but tradition considers NPI’s to be financial transaction without reserves ownership**



# *General Reserves Determination*

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## *Problems Identified by the SEC*

- Some abuses of the proved classification (in no particular order)
  - Spacing violations for PUDs
  - PUDs which are too optimistic based on supporting data
  - Seismic amplitudes for down dip limits
  - Use of non-hydrocarbon revenue streams
  - Misuse of reservoir simulation results
  - Field level decline curve analysis
  - Declining operating costs with declining well count
  - Allocation of development costs to probable category to justify proved reserves economics
  - Justification of proved reserves by analogy with non-analogous properties
  - Misuse of statistical analysis
  - Reserves being declared proved when no sales market exists
  - Scheduling of reserves which extend beyond the term of foreign concessions



# *What's on the Horizon*

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- SPE is revising its petroleum reserves definitions and will issue new ones in 2006-2007.
- The United Nations has integrated the SPE/World Petroleum Congress reserves definitions into its framework with an aim to fully align both.
- SPE is working with the International Accounting Standards Board and other organizations, including the UN, to ensure the adequacy of reserves standards.
- The IASB and FASB have agreed to work towards the convergence of existing U.S. and international financial accounting practices and the joint development of future standards.
- According to Roger Schwall, assistant director for the Division of Corporate Finance - the SEC has no current plans to change their definitions or guidelines.



**Reserves Reports**

**Reserves Audits**

**Reserves Reviews**



# RESERVE REPORT VS. AUDIT VS. REVIEW

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**Reserve Report -** grass roots evaluation in which the estimator has examined and evaluated all available source data.

**Reserves Audit -** an examination for the purpose of expressing an opinion that a reserve report is reasonable in the aggregate, and generally conforms to accepted engineering and geological evaluation principles.

**Reserves Review -** an analysis of the process and procedures established to assure that reserves have been estimated in compliance with relevant standards



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# Questions / Answers