

# RESOURCE PLAYS: UNDEVELOPED RESERVES

## “THE LEARNING CURVE”

Tennessee Oil and Gas Association  
Nashville, TN  
May 12, 2011

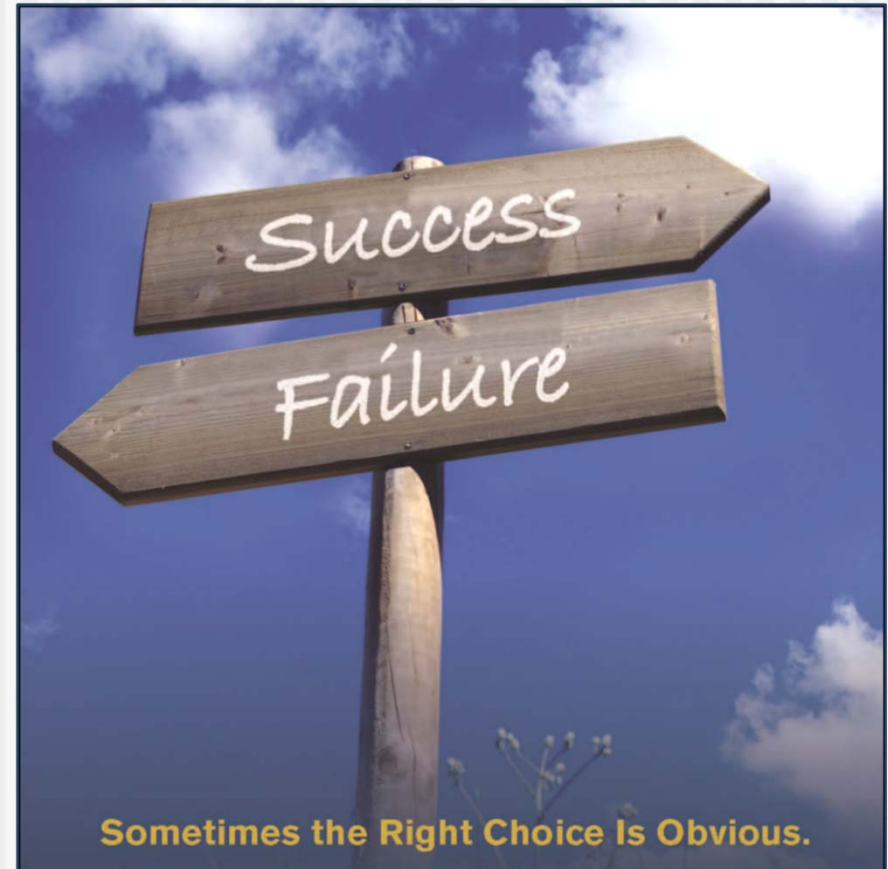


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Wright & Company, Inc.  
Petroleum Consultants

# Wright & Company, Inc.

Petroleum Consultants

## Our Mission

- Wright & Company, Inc. 's mission is to be client driven with the most reliable, responsive and cost effective professional services possible within the oil and gas industry. This mission is achieved with personal service, understanding, sound judgment and credibility.

## Experience

- Founded in 1988 by D. Randall Wright, P.E.
- With over 130 years of combined experience with major integrated and independent oil and gas companies, major financial institutions and various consulting firms, our engineers and geologists offer sound judgment, experience and dedication
- Clients include major and independent exploration and production companies, investment and commercial banks, law firms, individuals and other consulting firms for specific expertise.

## Services

- **Property Evaluations:** Evaluations of developed and undeveloped properties, both domestic and abroad, including facilities and development plans
- **Audits/Reasonableness Reviews:** Unbiased audits and opinions on both in-house and third party estimates of reserves and economics
- **Reservoir Analysis:** Formation evaluations, reservoir simulations, enhanced recoveries, work-overs, well testing, log analysis, operations and completion optimization
- **Acquisition and Divestiture:** Representation of sell-side, buy-side, joint venture opportunities and financial investments
- **Reserves Estimation:** Volumetric calculations, history match and performance, forecasting future production and cash flow

## Extensive Shale Expertise

- Marcellus/Devonian
- New Albany
- Haynesville-Bossier
- Huron
- Eagle Ford
- Antrim
- Niobrara
- Chattanooga

## Unconventional Resource Plays

- Coal Bed Methane
- Tight Gas Sands
- Vertical and Horizontal Drilling

## International Representation

- Representation of various companies throughout the world in due diligence, reserves and economic analysis for investment opportunities in emerging US shale plays including Marcellus, Eagle Ford and Niobrara

## Mid-Stream

- Evaluations of development plans, Estimated Ultimate Recovery determination, estimating pipeline volumes and future production rates and anticipated sales volumes

## Fair Market Value

- Fairness opinions, negotiations, borrowing base determination for bank financing

# NORTH AMERICAN SHALE PLAYS



# WHAT IS A RESOURCE PLAY

## TIER 1 CRITERIA

1. Wells exhibit a repeatable statistical distribution
2. Offset well performance is **NOT** a reliable predictor
3. Continuous hydrocarbon system is regional in extent
4. Free hydrocarbons (non-sorbed) are not held by hydrodynamics

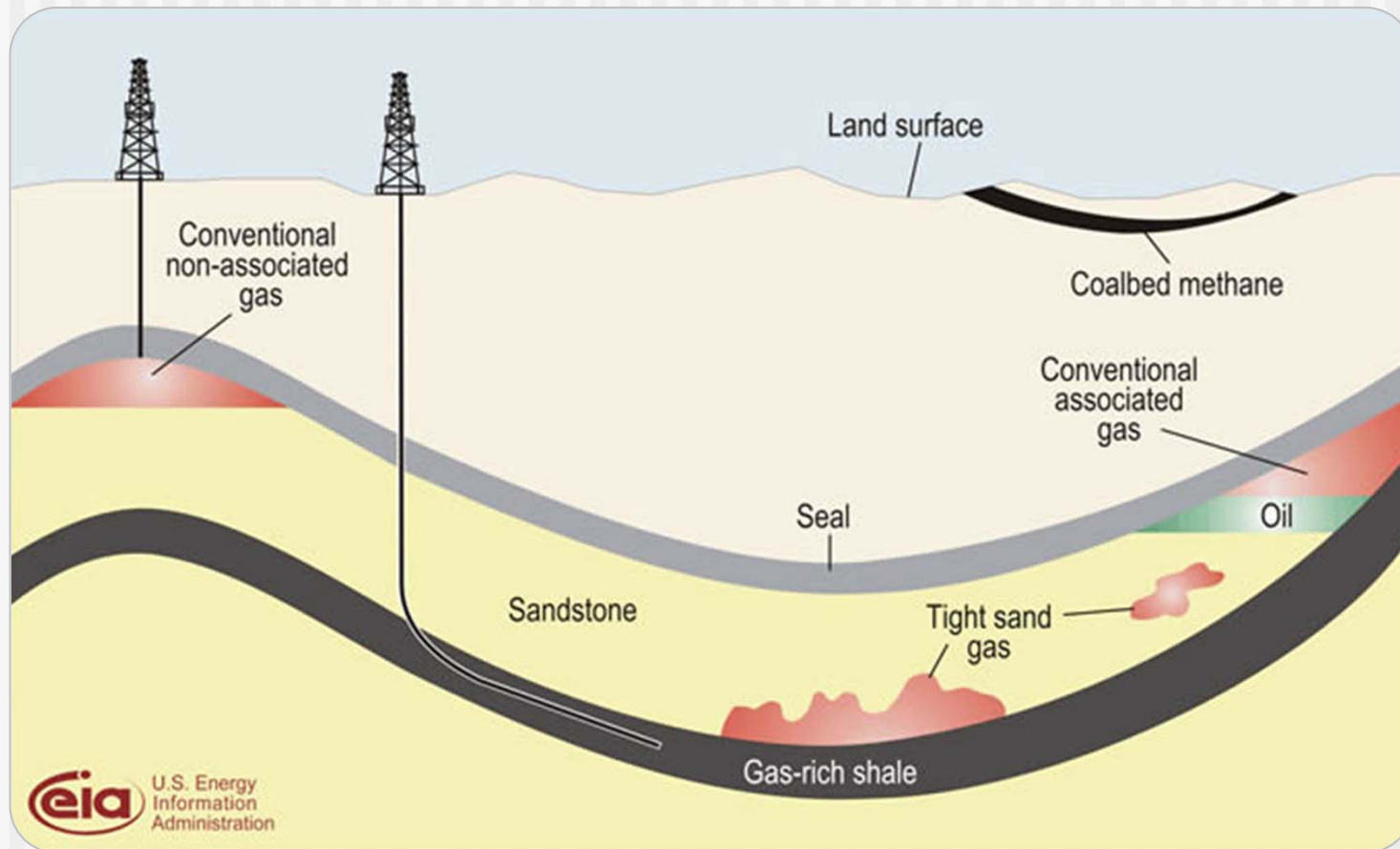
## TIER 2 CRITERIA

5. Requires extensive stimulation to produce economically
6. Produces little water
7. Does not exhibit an obvious seal or trap (geologically)
8. Low permeability (<0.1 millidarcies)

# THE STATISTICAL NATURE OF RESOURCE PLAYS

- Large areal extent but **NOT** homogenous
- Geologic or reservoir parameters **NOT** predictable at a specific well location
- Performance different → due to rock variability
- Consistency of repeatable results
- Wright's experience suggests that EURs usually exhibit a log-normal distribution
- Resource plays can become highly predictable **IF** there is a large sample size

# SCHEMATIC GEOLOGY OF NATURAL GAS RESOURCES



# TYPES OF RESOURCE PLAYS

## ➤ Shale Gas

- Defined as natural gas from shale formations
- Devonian Shale gas in Appalachia study by DOE began in 1968
- Shale acts as both 'source' and 'reservoir' derived from thermogenic processes
- Gas occurs as free gas in pore space and sorbed gas
- Nanodarcy permeability
- Requires large hydraulic fracture stimulations

# TYPES OF RESOURCE PLAYS

- Shale Gas
- Tight Gas Reservoirs
  - Defined as “having permeability to gas  $<0.1$  millidarcies”
  - Require massive hydraulic fractures stimulations to produce commercial quantities
  - At least 20 U. S. basins with tight gas sands
  - More than 13 additional basins are speculative (prospective)

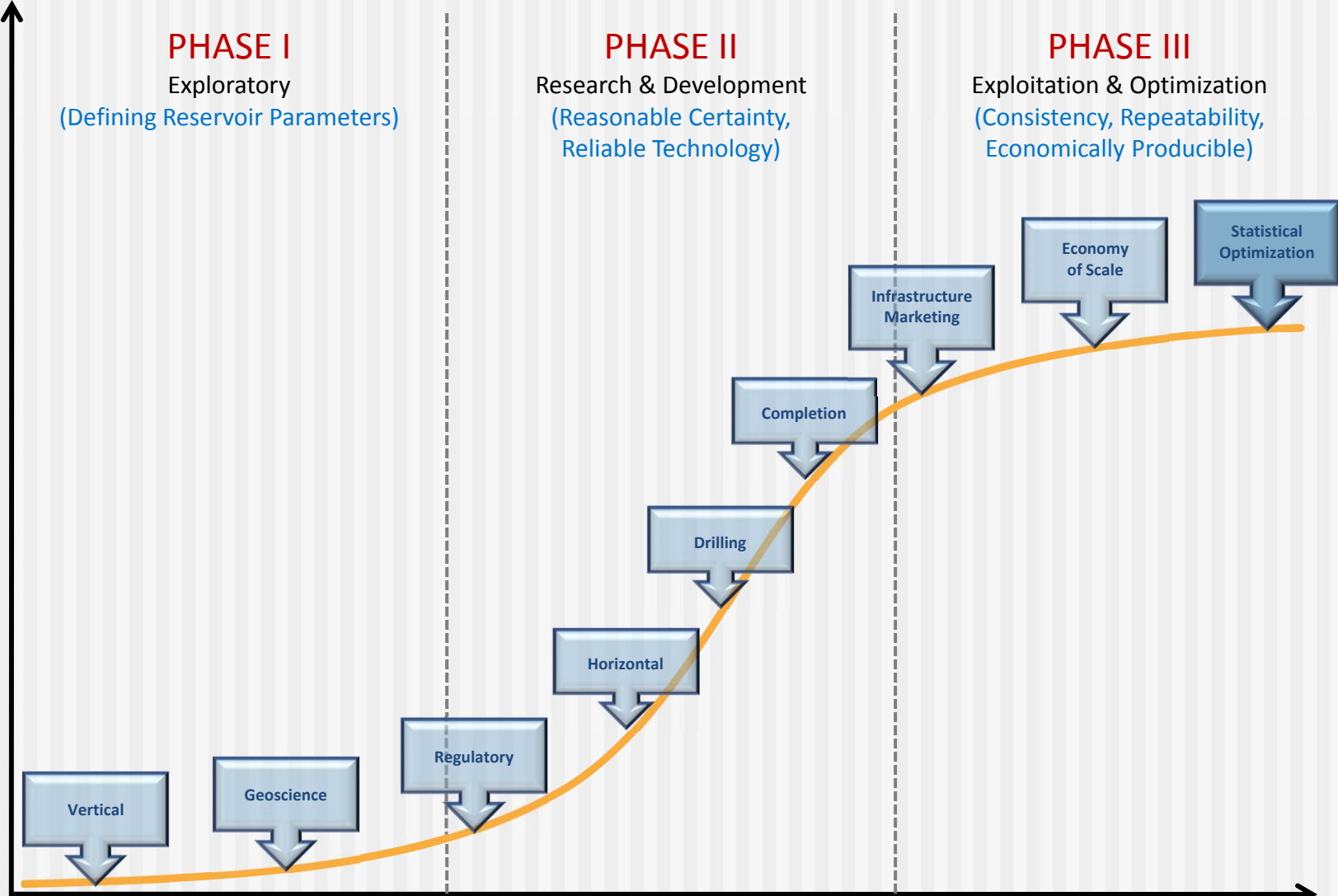
# TYPES OF RESOURCE PLAYS

- Shale Gas
- Tight Gas Reservoirs
- Tight Oil Reservoirs
  - New to resource play category
  - But fulfills the Tier 1 criteria
  - Also fulfills most of Tier 2 criteria

# TYPES OF RESOURCE PLAYS

- Shale Gas
- Tight Gas Reservoirs
- Tight Oil Reservoirs
- Coal Bed Reservoirs
  - Methane Produces
    - Pressure reduced de-sorbed
    - Dewatering

# RESOURCE PLAY LEARNING CURVE



As the Number of Wells Drilled Increased

# SHALE GAS EVALUATION CONSIDERATIONS

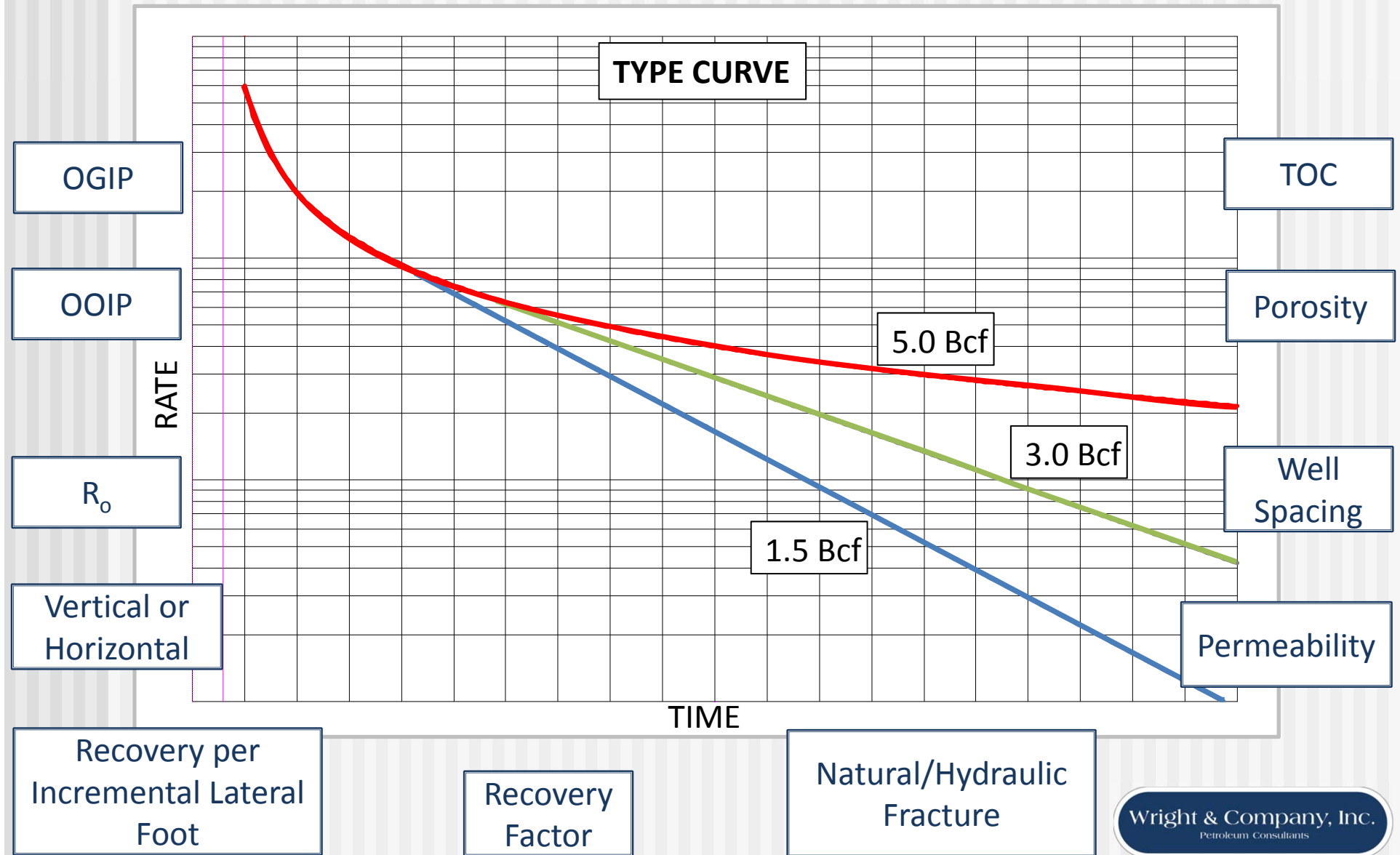
- Shale plays may require considerable initial capital expenditures to allow commercial access and determine economic feasibility.
- Geoscience costs tend to be very large early in shale plays:
  - Seismic in areas without recent petroleum exploration activity
  - Coring and laboratory analysis
- Learning curve – earliest wells in new play may deliver poor results as drilling and completion technology is perfected.
- General shale play economics improve over time due to:
  - More effective drilling and completion techniques
  - Better understanding of reservoir and identification of “sweet spots”
- Long-term investment
  - Shale gas plays have very large in-place volumes and very large drilling location inventories that may take decades to realize.

# RESOURCE “SHALE” PLAYS

## KEY QUESTIONS:

- How much oil and/or gas are wells going to produce?
- Can we make money drilling wells?

# FACTORS INFLUENCING WELL RECOVERY AND ECONOMICS



# ESTIMATING UNDEVELOPED RESERVES IN A RESOURCE PLAY

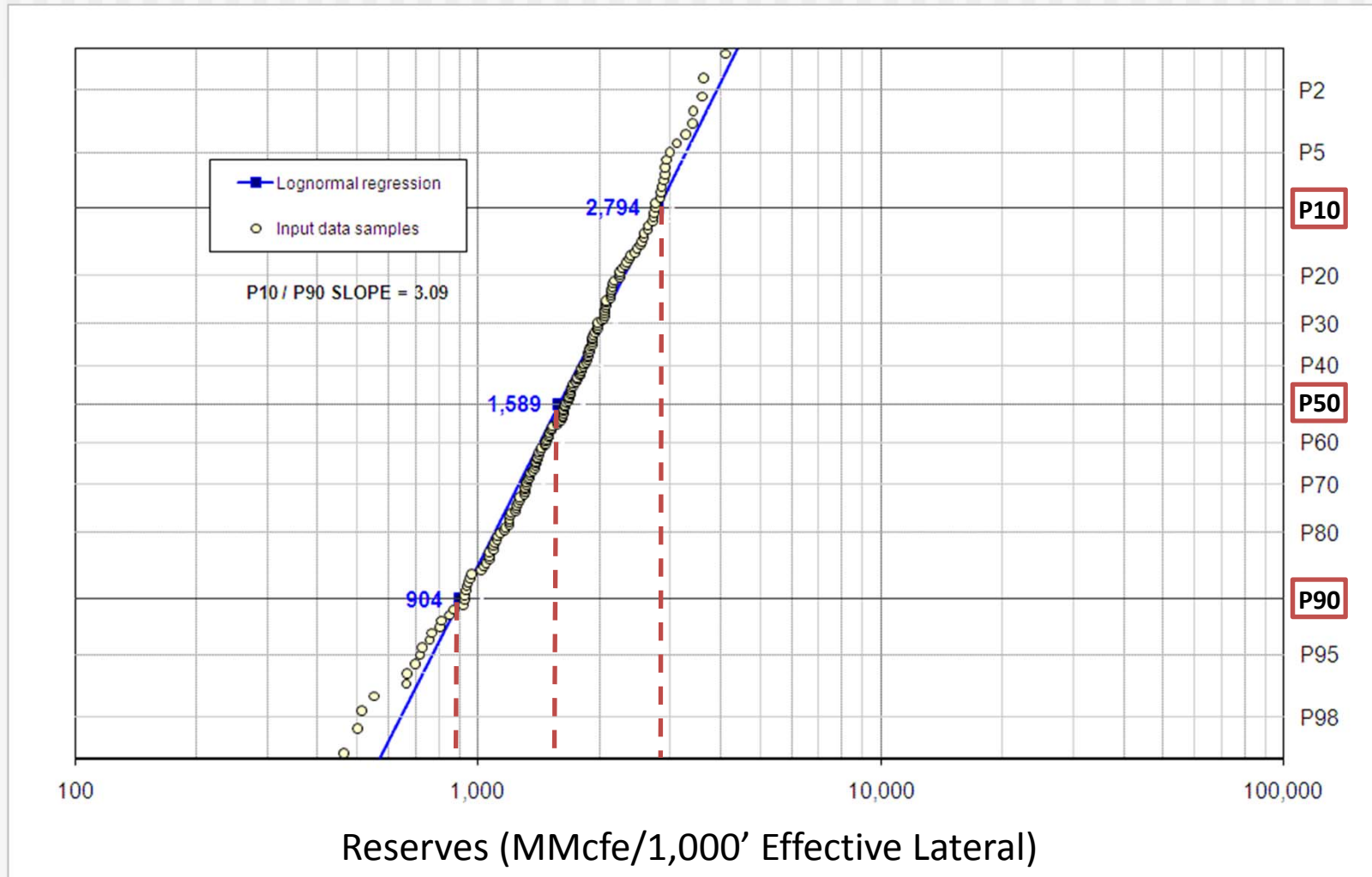
- Identify analogous wells
  - Wells exhibit a **repeatable** statistical distribution
  - Past performance can determine future performance
    - > Identify historical data for reserves and performance
    - > Prepare a statistical model
  - Common parameters of timing, technology, and geology
    - > Timing – Operators gain knowledge → performance improves
    - > Technology – Formation, Completion, Operational
    - > Geology –
      - Same geological formation
      - Same environment of deposition
      - Similar geological structure
      - Same drive mechanism

# ESTIMATING UNDEVELOPED RESERVES IN A RESOURCE PLAY

- Create a statistical distribution for analogous wells
  - EUR, EUR/foot, Peak Rate

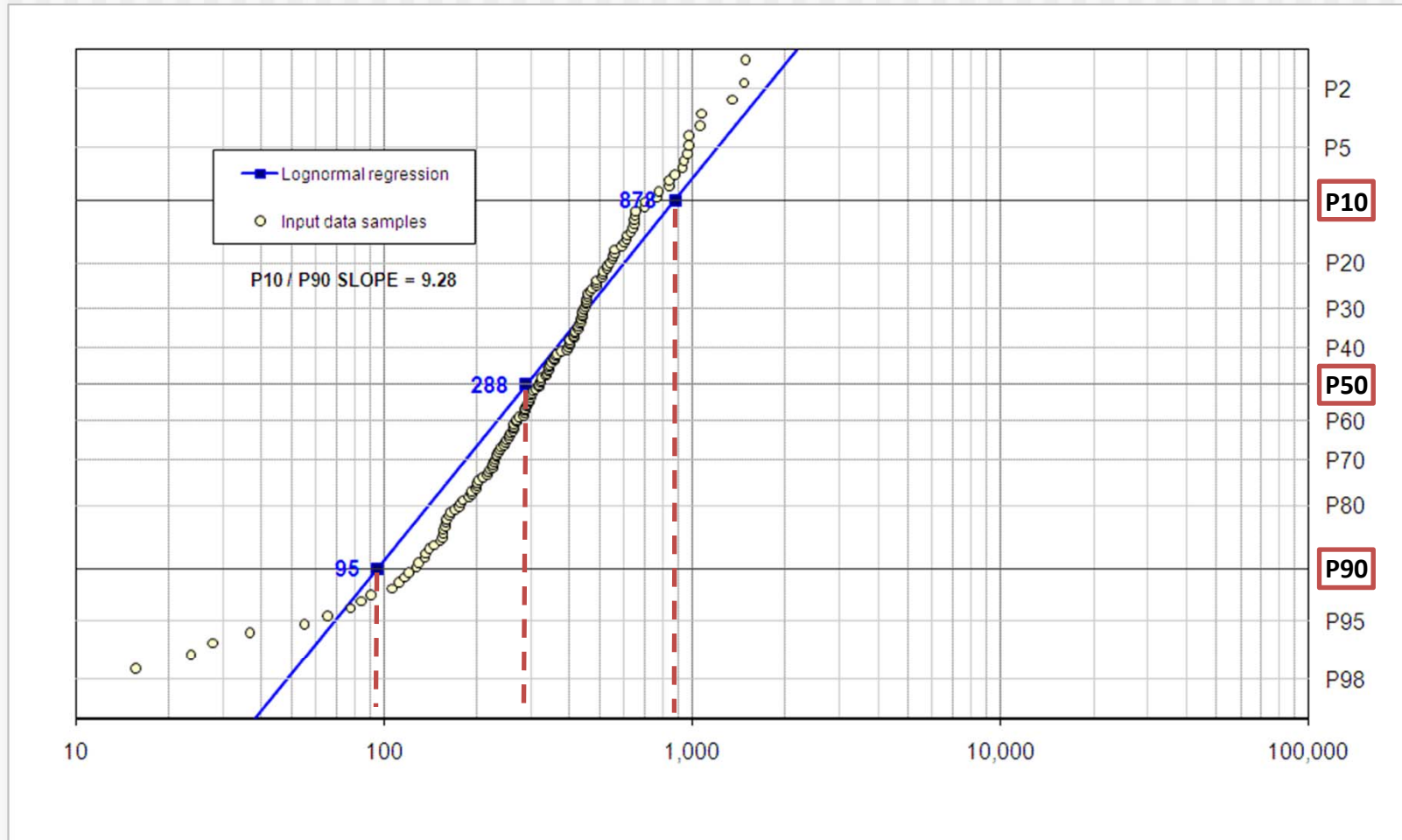
# LOG NORMAL PLOT

## RESOURCE PLAY - HORIZONTAL WELL



# LOG NORMAL PLOT

## RESOURCE PLAY - VERTICAL WELL



# ESTIMATING UNDEVELOPED RESERVES IN A RESOURCE PLAY

- Create a statistical distribution for analogous wells
  - EUR, EUR/foot, Peak Rate
- Determine number of opportunities (well count)
  - Spacing – Acreage
  - Location “drillability”

# PHASES OF RESOURCE PLAY DEVELOPMENT - PDP

	Early	Intermediate	Statistical	Mature
<b>RATIO OF ANALOGOUS PRODUCING WELLS TO RECOMMENDED SAMPLE SIZE</b>	< 1	1 to 4	> 3	Very Large
<b><math>P_{10}/P_{90} &lt; 4</math>, APPROXIMATE WELL COUNT</b>	< 50	100	150	> 500
<b><math>P_{10}/P_{90}</math> 4 TO 10, APPROXIMATE WELL COUNT</b>	< 50-200	100-400	150-600	> 1000
<b><math>P_{10}/P_{90}</math> 10 TO 30, APPROXIMATE WELL COUNT</b>	< 200-700	200-1400	600-2100	> 4500

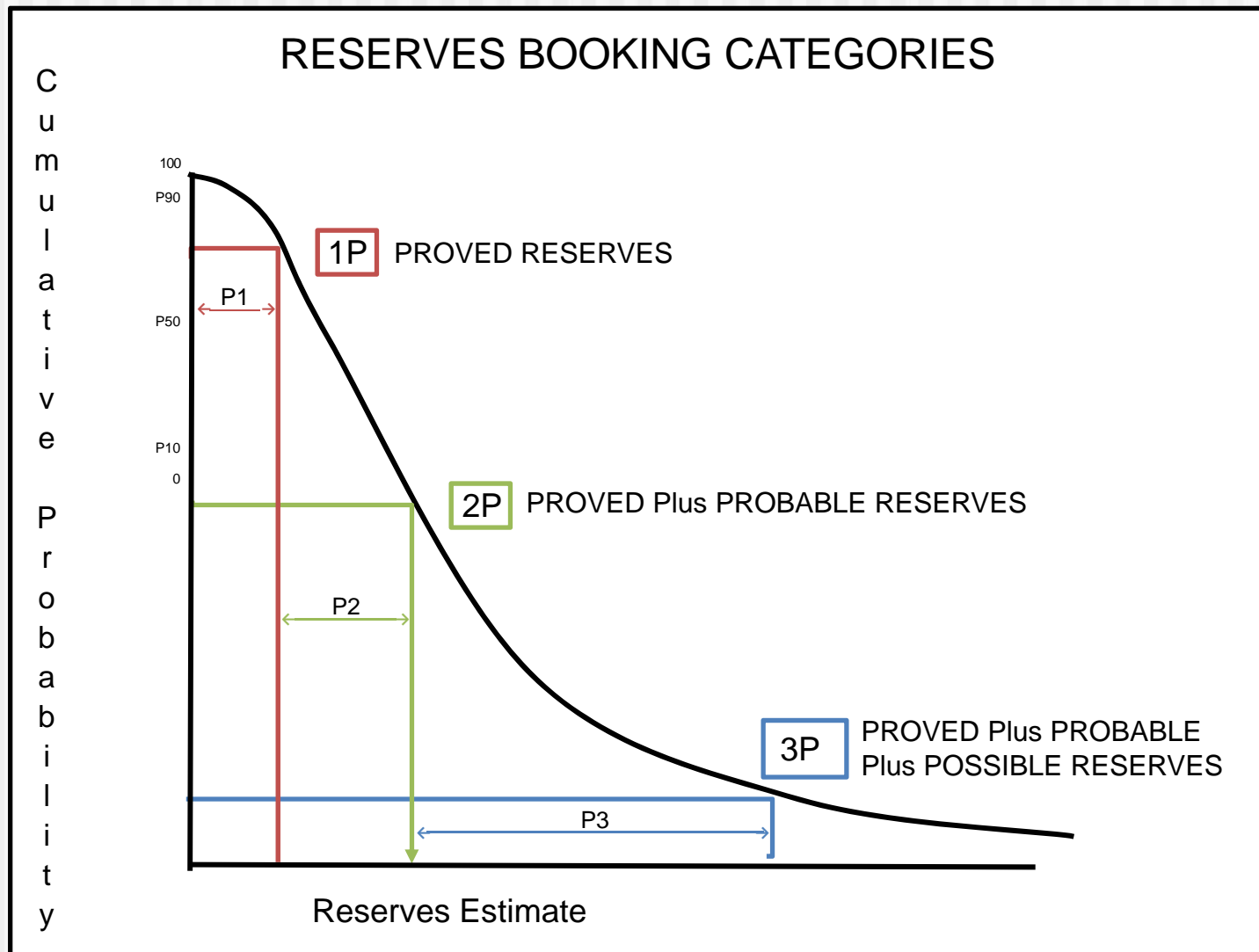
# PHASES OF RESOURCE PLAY DEVELOPMENT - PUD

	PHASE OF RESOURCE PLAY DEVELOPMENT			
	Early	Intermediate	Statistical	Mature
RECOMMENDED NUMBER OF PUD OFFSETS PER PRODUCING WELL (VERTICAL WELLS)	4	8	Statistical	Statistical
RECOMMENDED NUMBER OF PUD OFFSETS PER PRODUCING WELL (HORIZONTAL WELLS)	2-4	4-8	Statistical	Statistical

# ESTIMATING UNDEVELOPED RESERVES IN A RESOURCE PLAY

- Create a statistical distribution for analogous wells
  - EUR, EUR/foot, Peak Rate
- Determine number of opportunities (well count)
  - Spacing – Acreage
  - Location “drillability”
- Calculate reserves
  - PRMS (Petroleum Resource Management System)
    - > SPE, SPEE, AAPG, and WPC
    - > P<sub>90</sub> quantities actually produced or exceed the estimate

# ESTIMATING UNDEVELOPED RESERVES IN A RESOURCE PLAY



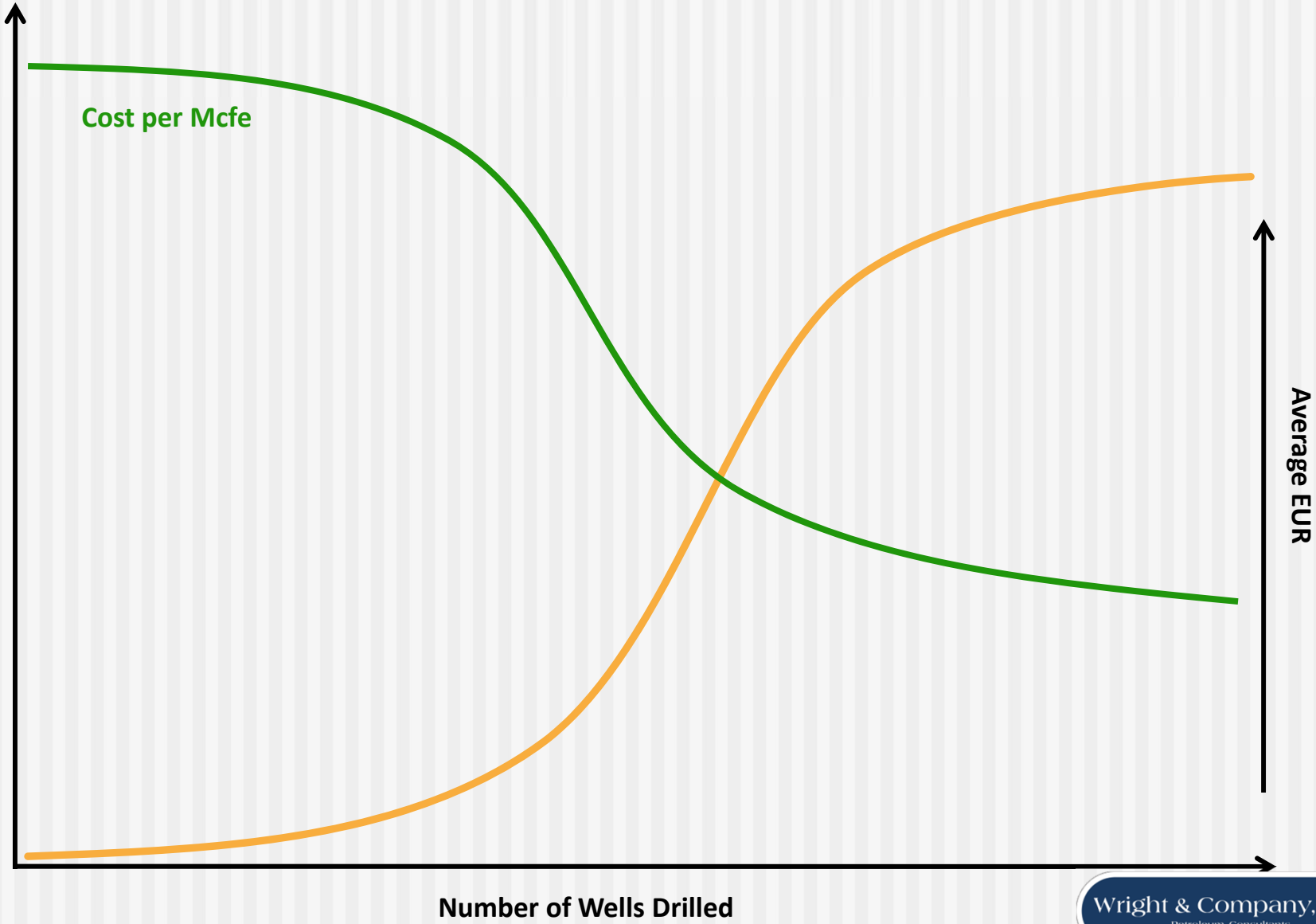
# RISKS AND ONGOING CHALLENGES

- Rig and service crew availability
- Placement of laterals, effectiveness of completions
- Water use and disposal
- Gas leakage and groundwater contamination issues
- Pipeline capacity, transportation bottlenecks
- Plants, processing and installation
- Gas and liquids pricing

# WHAT DOES WRIGHT EXPECT NOW?

- More wells » more data » more accurate reserves estimates
- Resource plays to continue rapid development toward statistical and mature phases
- Drilling/Completion techniques continue to improve
- Infrastructure to provide outlets to markets
- Average EURs, lateral lengths, optimal spacing, efficiencies to be more clearly defined

# RESOURCE PLAYS LEARNING CURVE



# ESTIMATING RESERVES

- There are **Known-Knowns** – Things we know that we know
- There are **Known-Unknowns** – Things we know that we do not know
- There are **Unknown-Unknowns** – Things we do not know that we do not know.

- Former U.S. Secretary of Defense Donald Rumsfeld

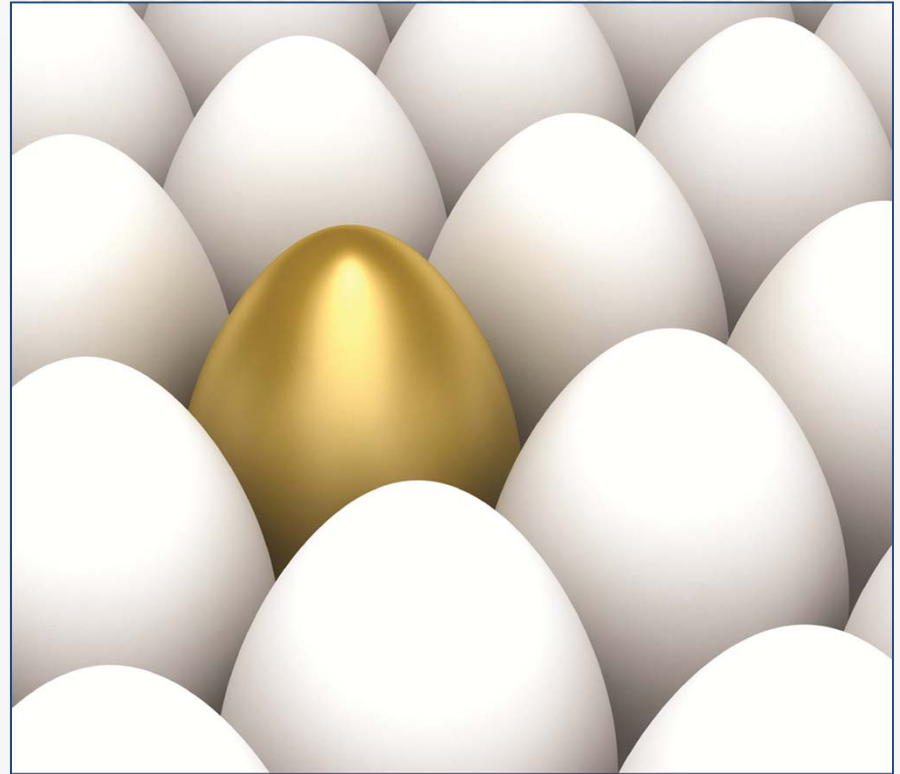
# THANK YOU!

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*Sometimes the **Wright** choice is obvious.*

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