

A Modified Approach to Coalbed Methane Exploration-What Have We Learned in the Past 20 Years?

- Charles M. Boyer and Stephen W. Lambert
- Data & Consulting Services
- Pittsburgh, Pennsylvania

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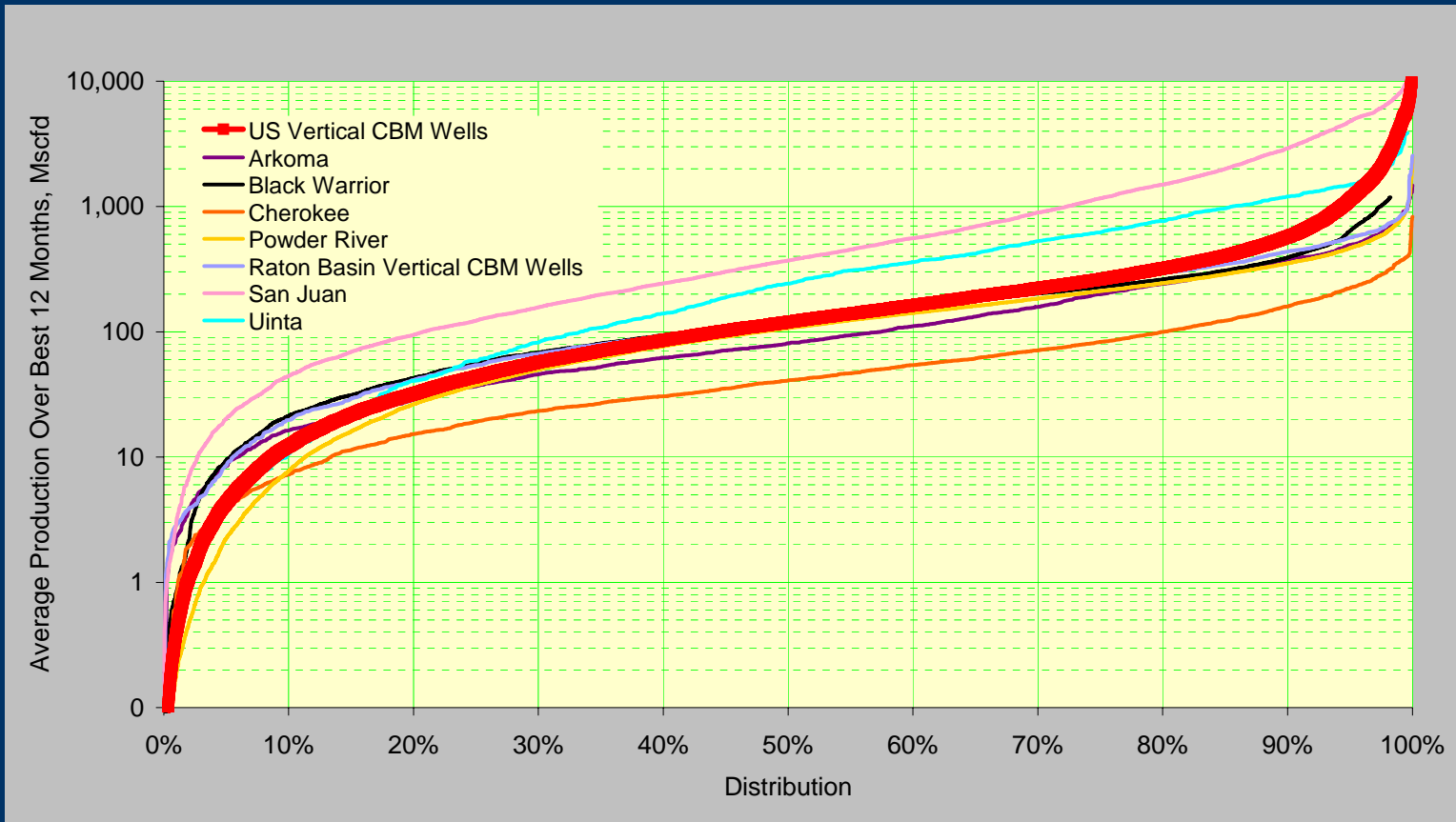
Houston, Texas

2006

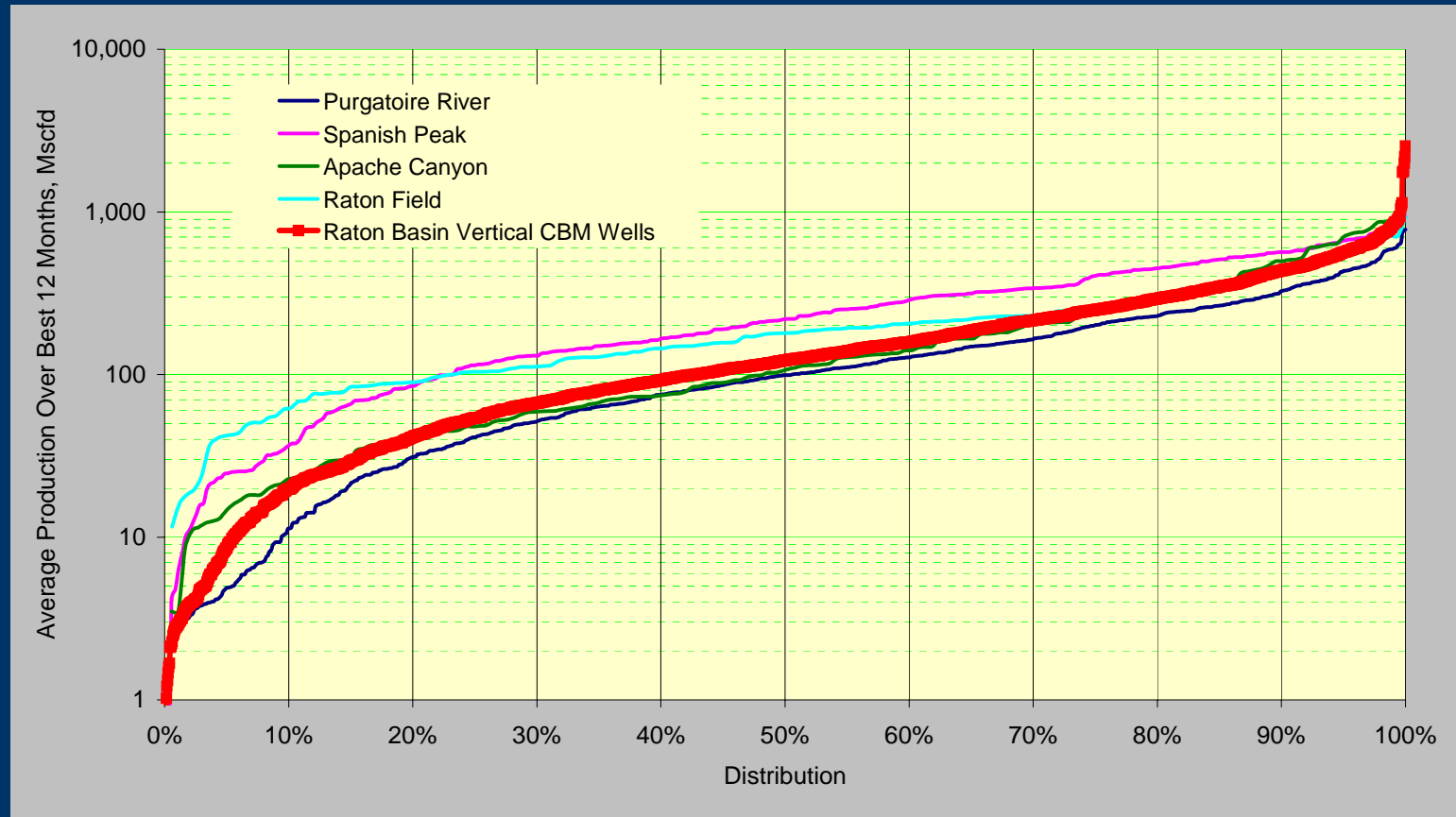
Presentation Outline

- ❖ Variability in Coalbed Methane Production
- ❖ Principle Causes of Production Variability
- ❖ An Alternative Exploration Approach

Basin-to-Basin Production Variability



Raton Basin Field-to-Field Production Variability



Principle Causes of Production Variability

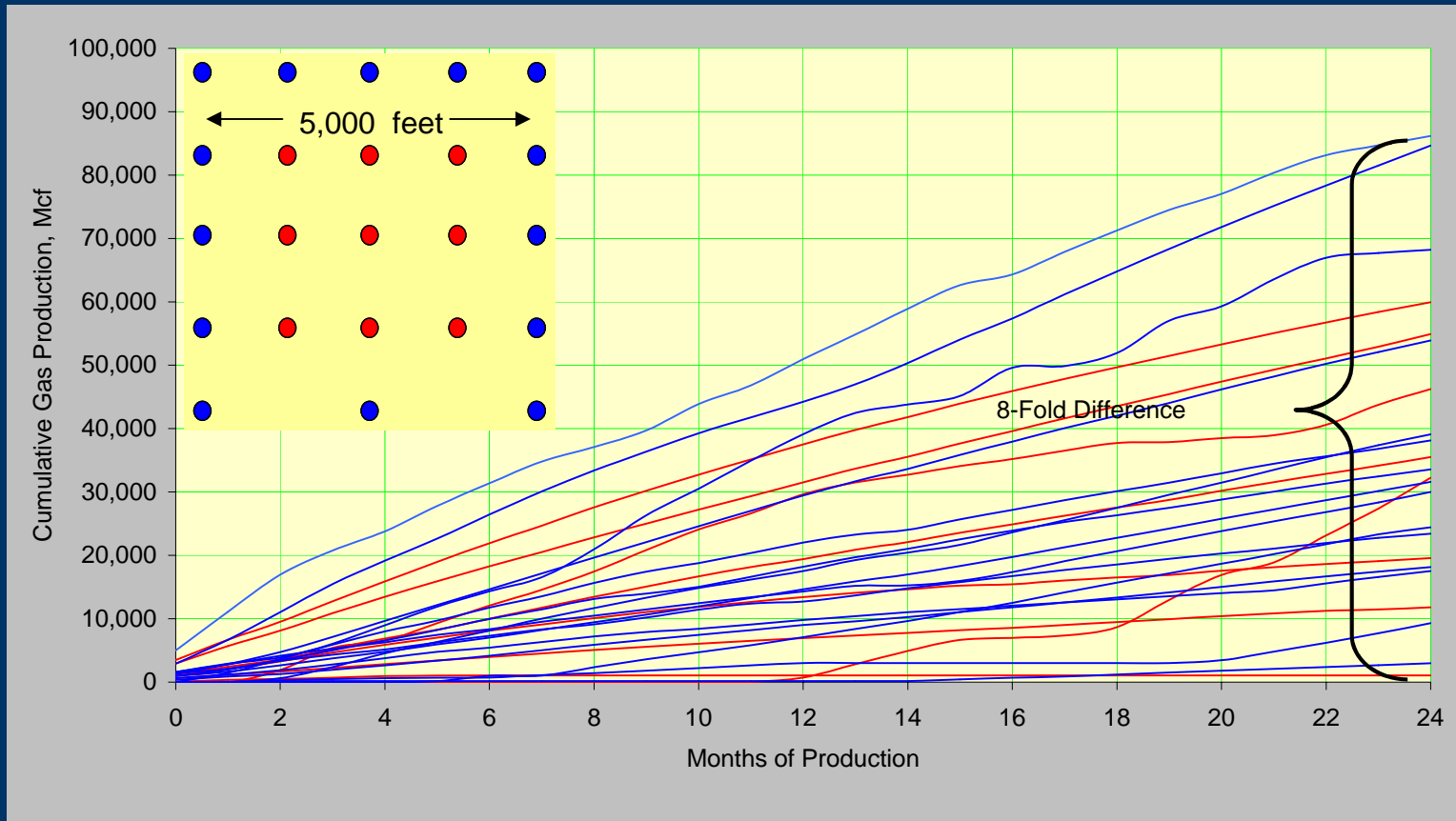
Variations of Resource?

- Generally regional in nature
 - Coal thickness
 - Gas content/sorption characteristics
 - Reservoir pressure

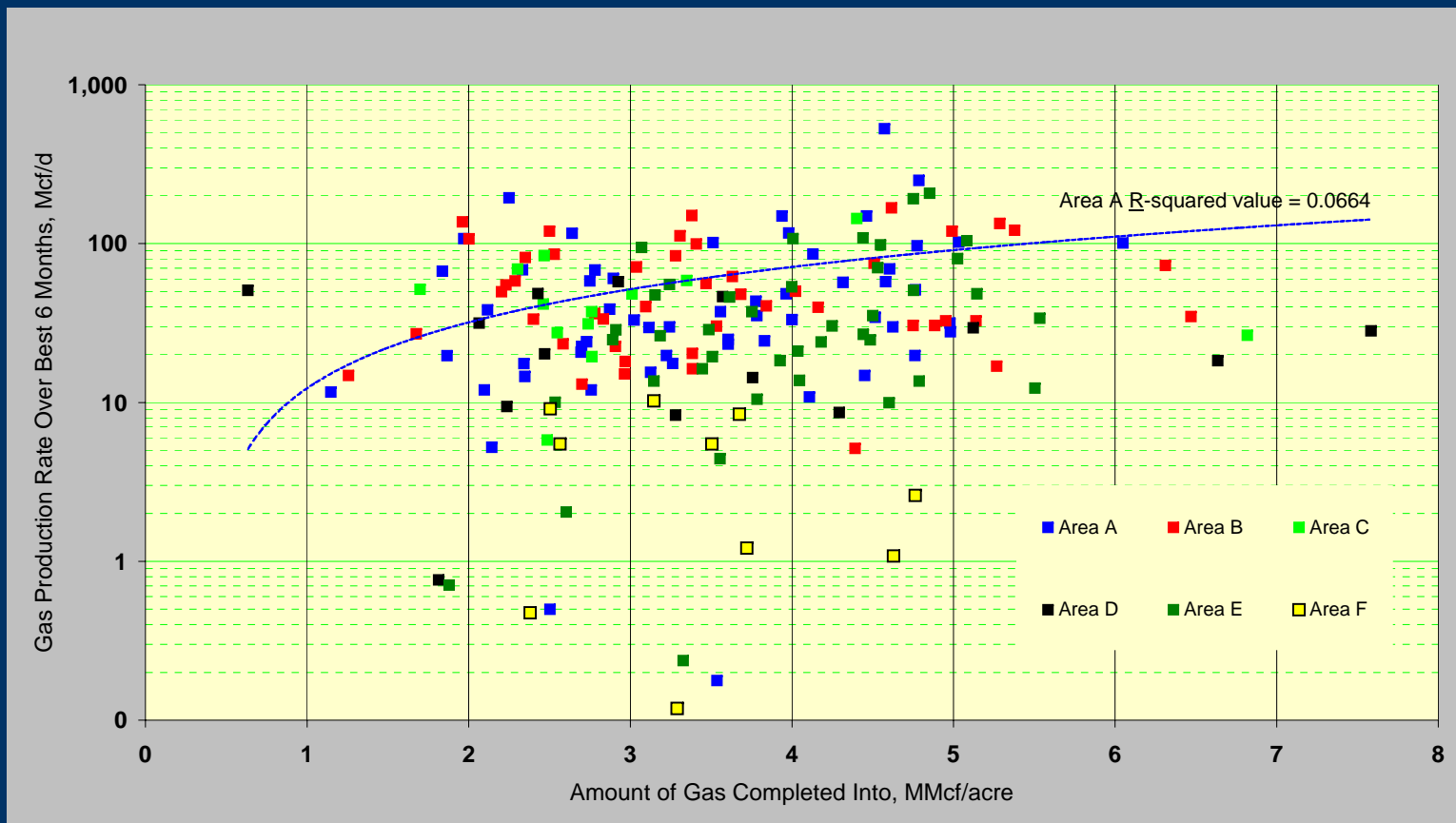
Variations of flow rate capacity?

- Often small scale – feet to tens of feet
- Permeability (naturally fractured reservoir) primary cause of variability

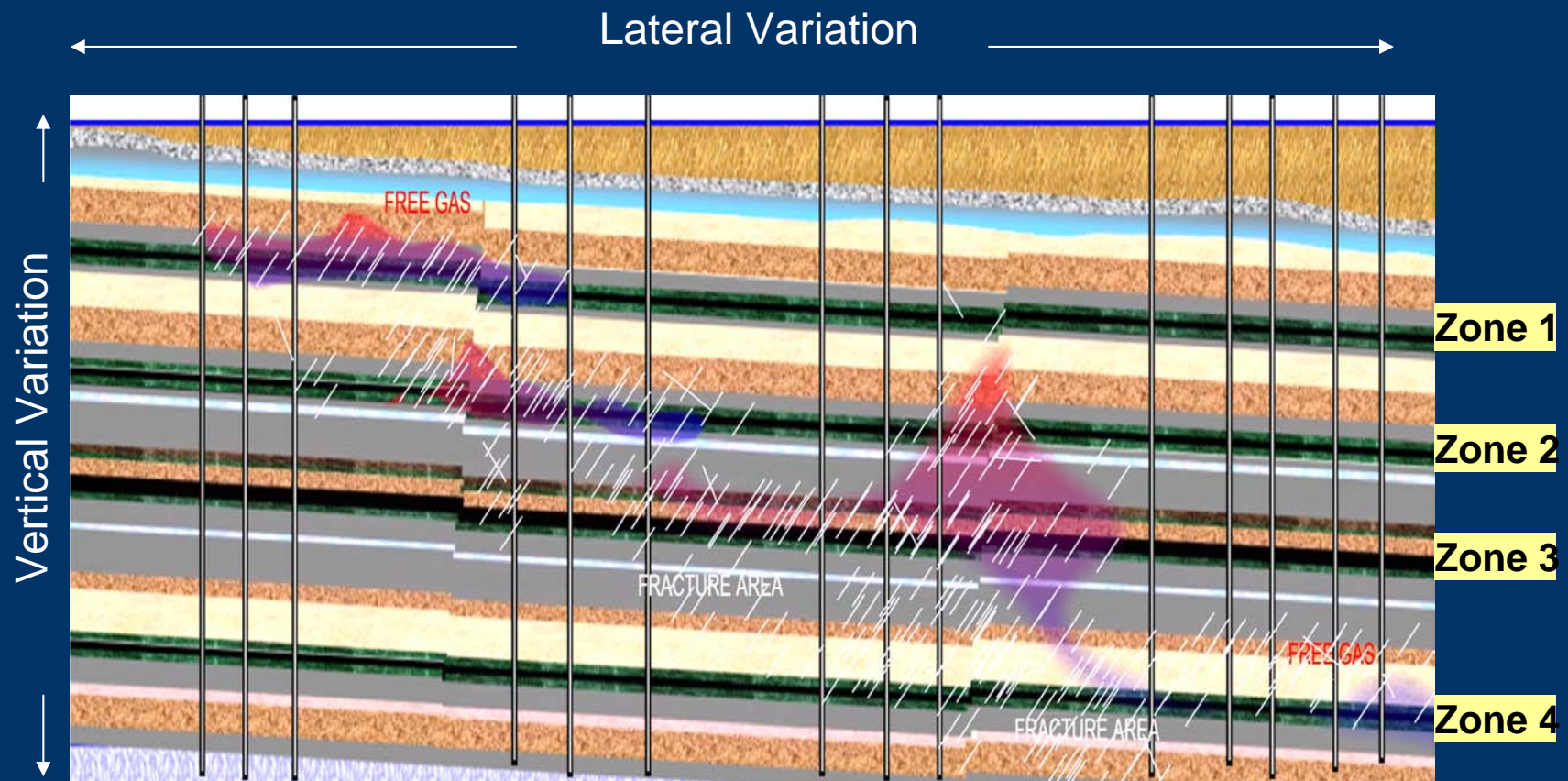
Equal Resource Base and Pressure Yields Widely Different Production



Rate Variability \neq Resource Variability



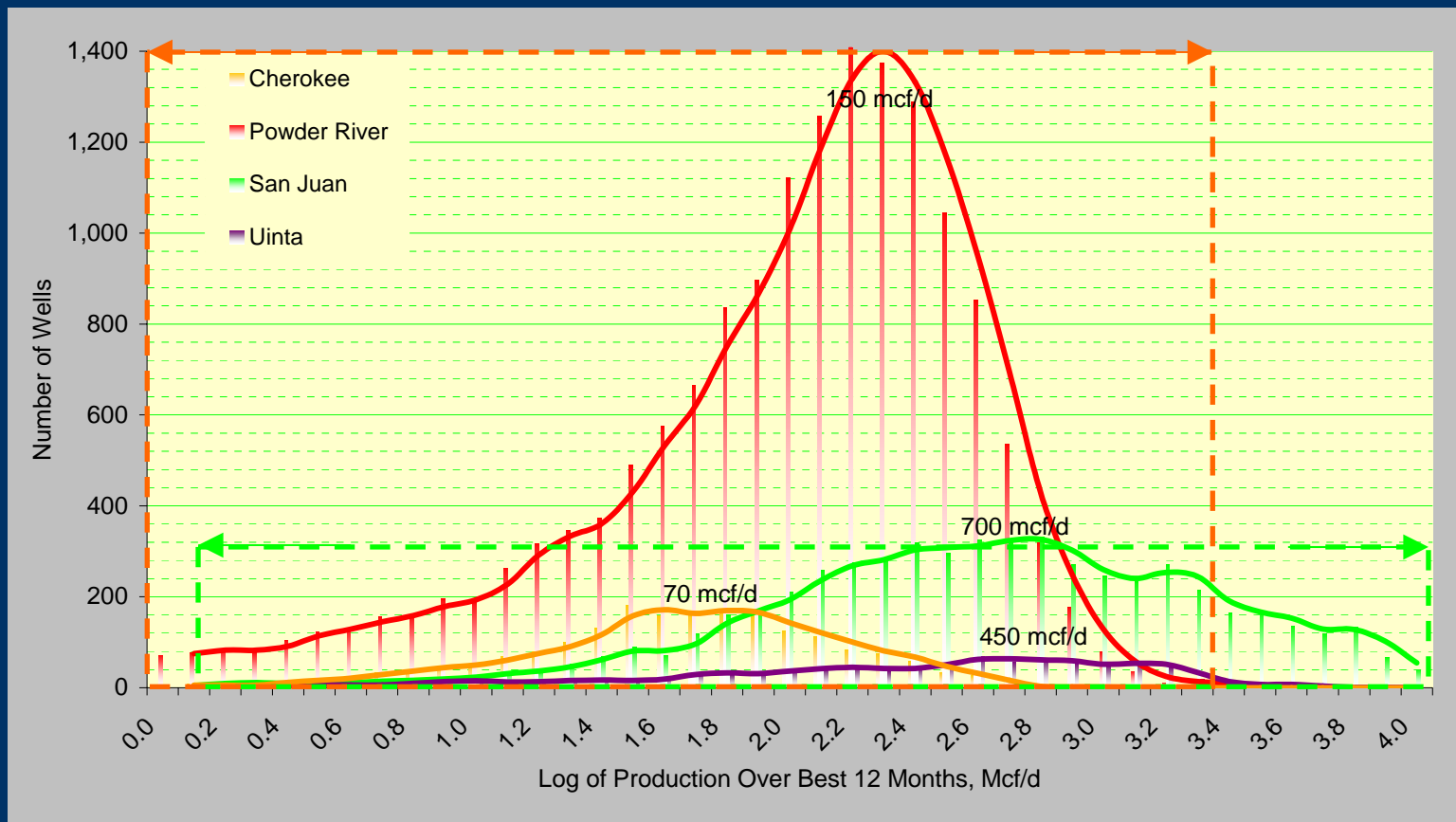
Rate Variability = Permeability Variability



How Can I Anticipate Production Average and Variability?

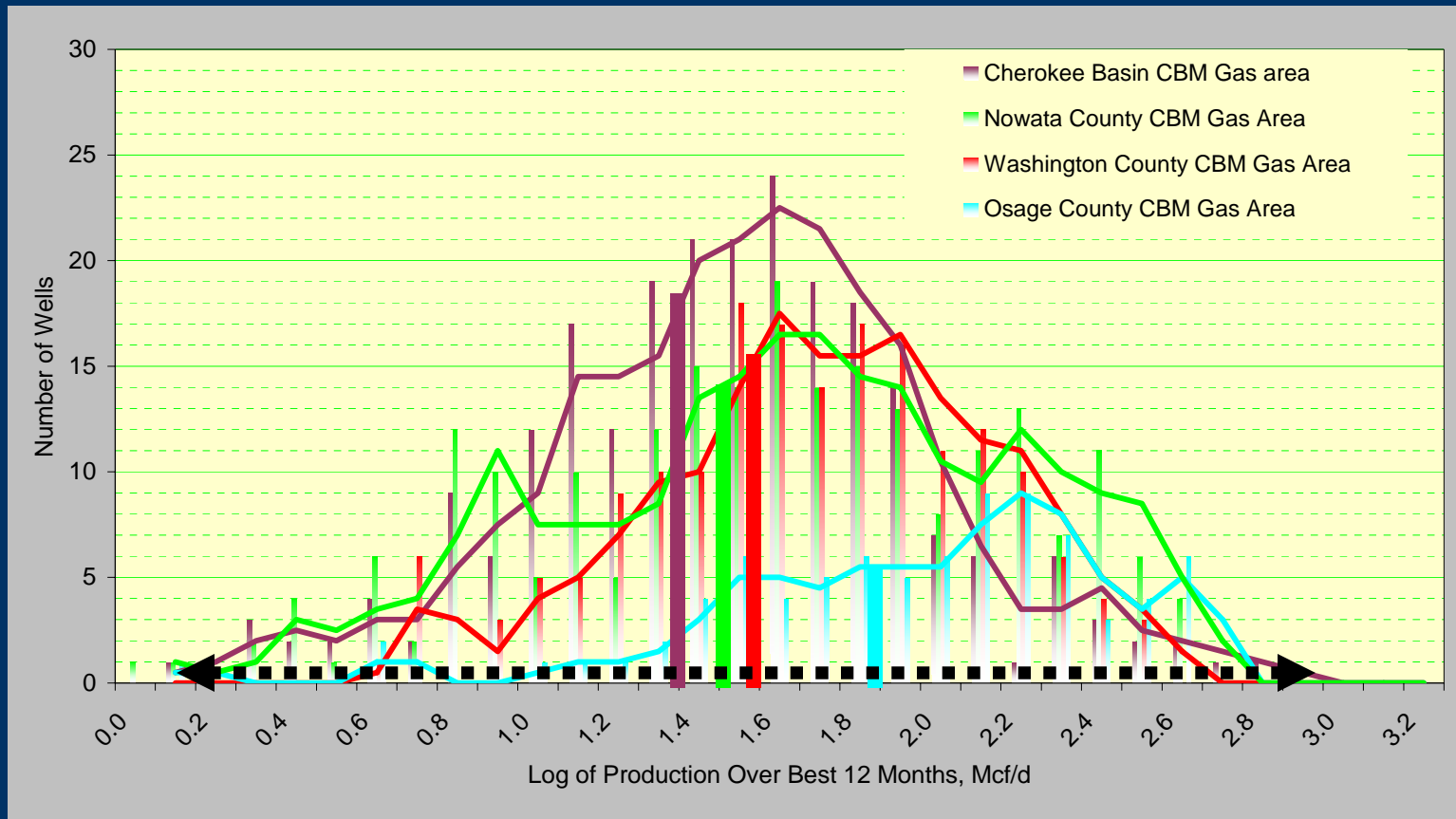
- ❑ Use historical data from existing producing basins and fields
- ❑ Employ statistical sampling methods to develop models for each project exploration area
- ❑ Apply traditional test site selection or non-traditional random test well selection methods

Use Historical Basin Data



Use Historical Field Data

Average gas rate changes with area location within basin, but the rate range remains about the same



Employ Statistical Sampling Methods

- ❑ Numerous production wells are required to begin to understand production variability
 - Generally, at least 10% of the acreage needs to be drilled to achieve 90% confidence and $< 30\%$ error
- ❑ Lowest technical but highest cost-related risk

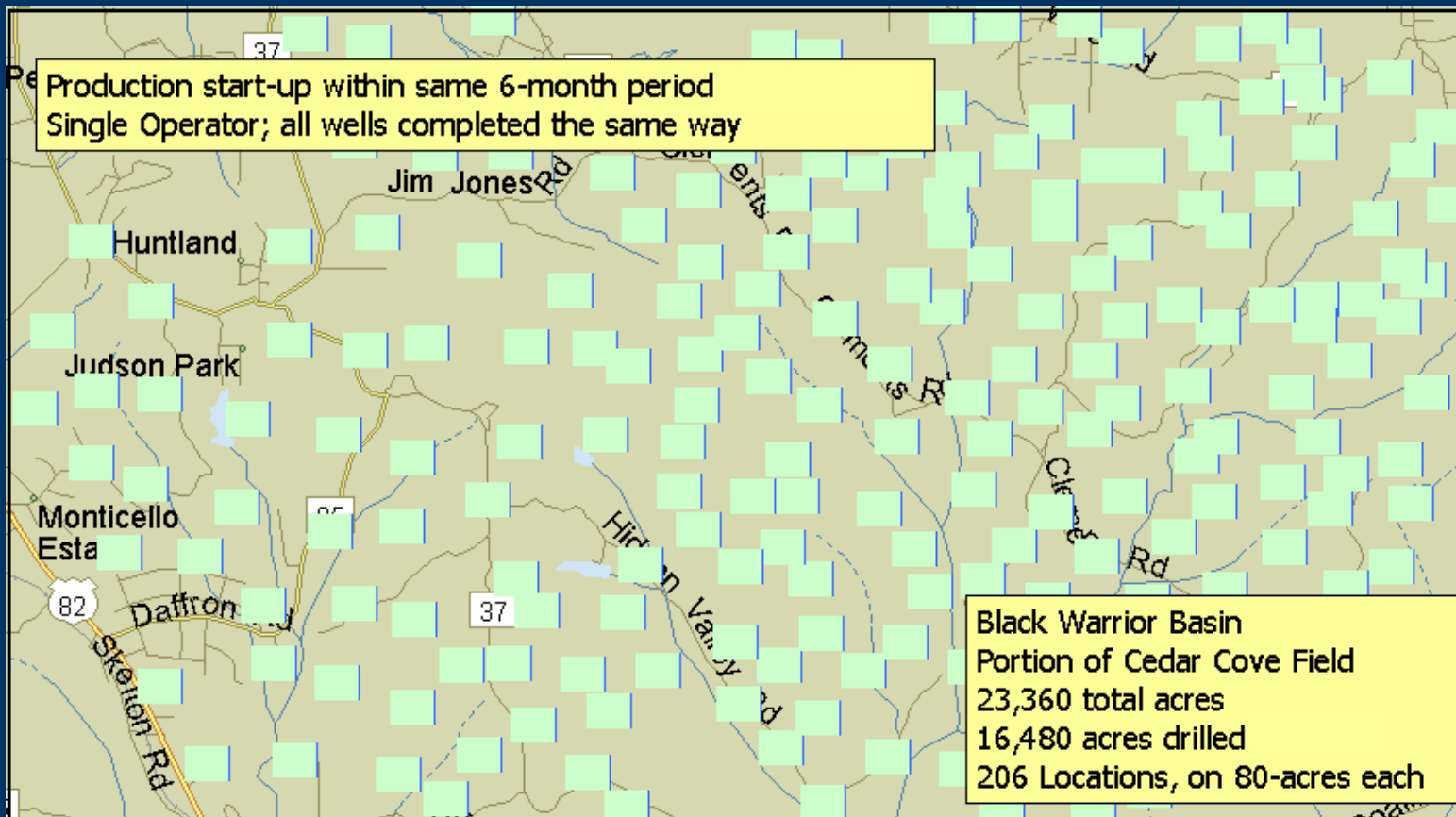
Apply Traditional Coalbed Methane Exploration Methods

1. Gather and evaluate data to develop a project model
 - Historical Data / Geology and "Closology"
 - Drill core holes / strat test wells
2. Identify optimum areas based on selected criteria
 - Coal thickness and gas in place - **The resource**
 - Rock Character / Flow Capacity / Other Qualities - **The romance**
 - Infrastructure - **The project area circumstance**
3. Pilot testing "5-spot" well patterns
 - Measure and evaluate results
4. Expand project or abandon

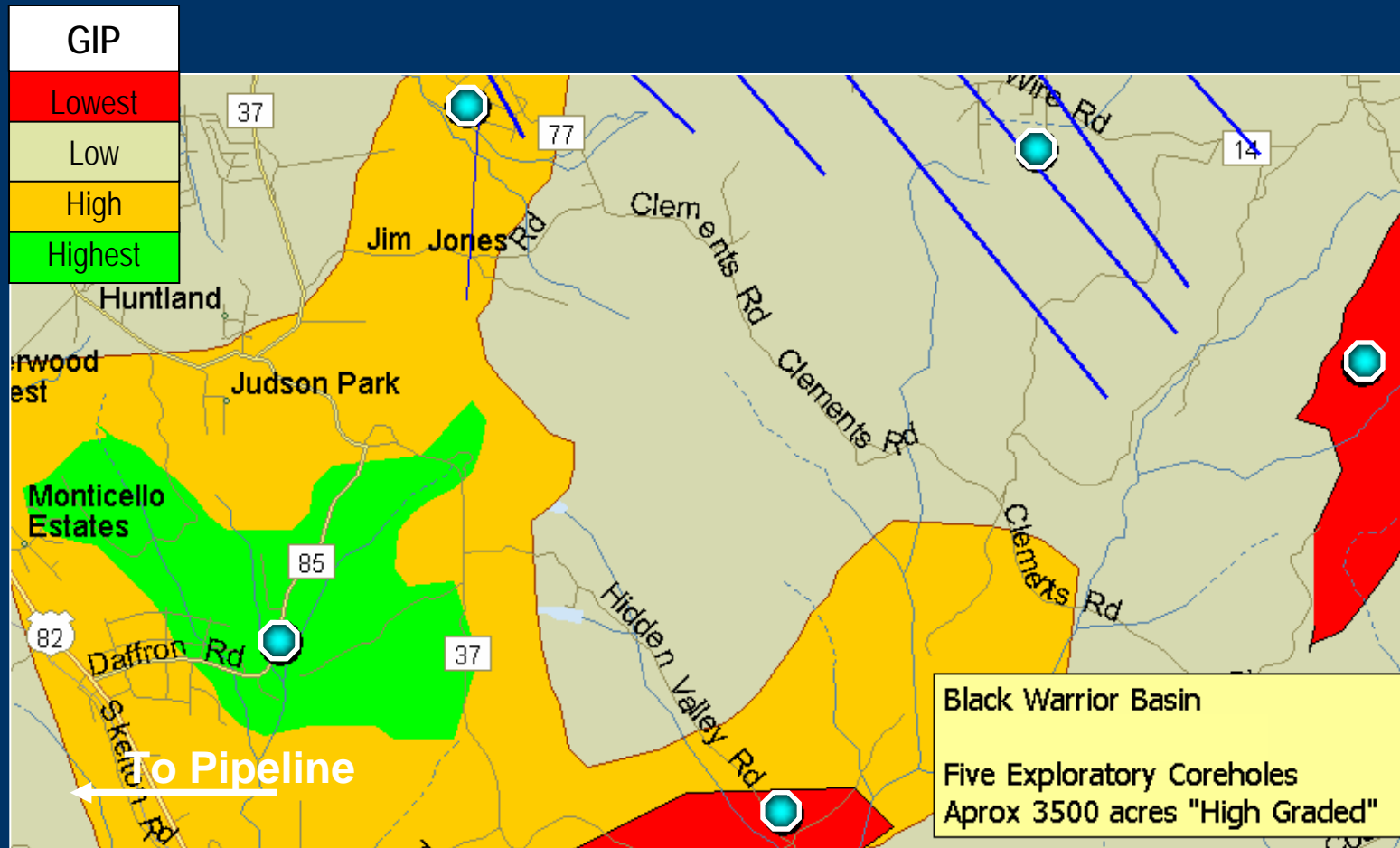


The paradigm

Example of Traditional Exploration- A Study in Hindsight

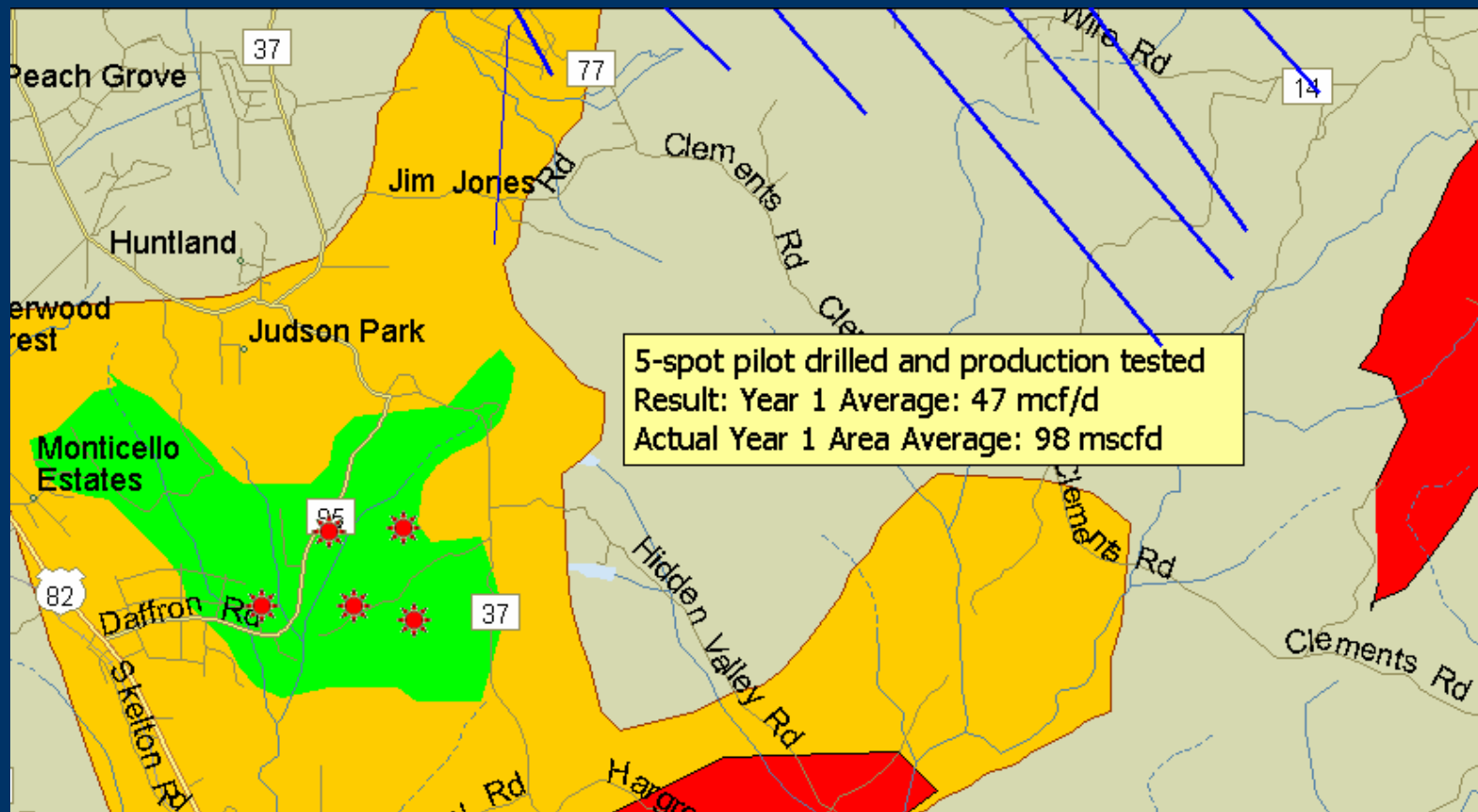


Example of Traditional Exploration- A Study in Hindsight



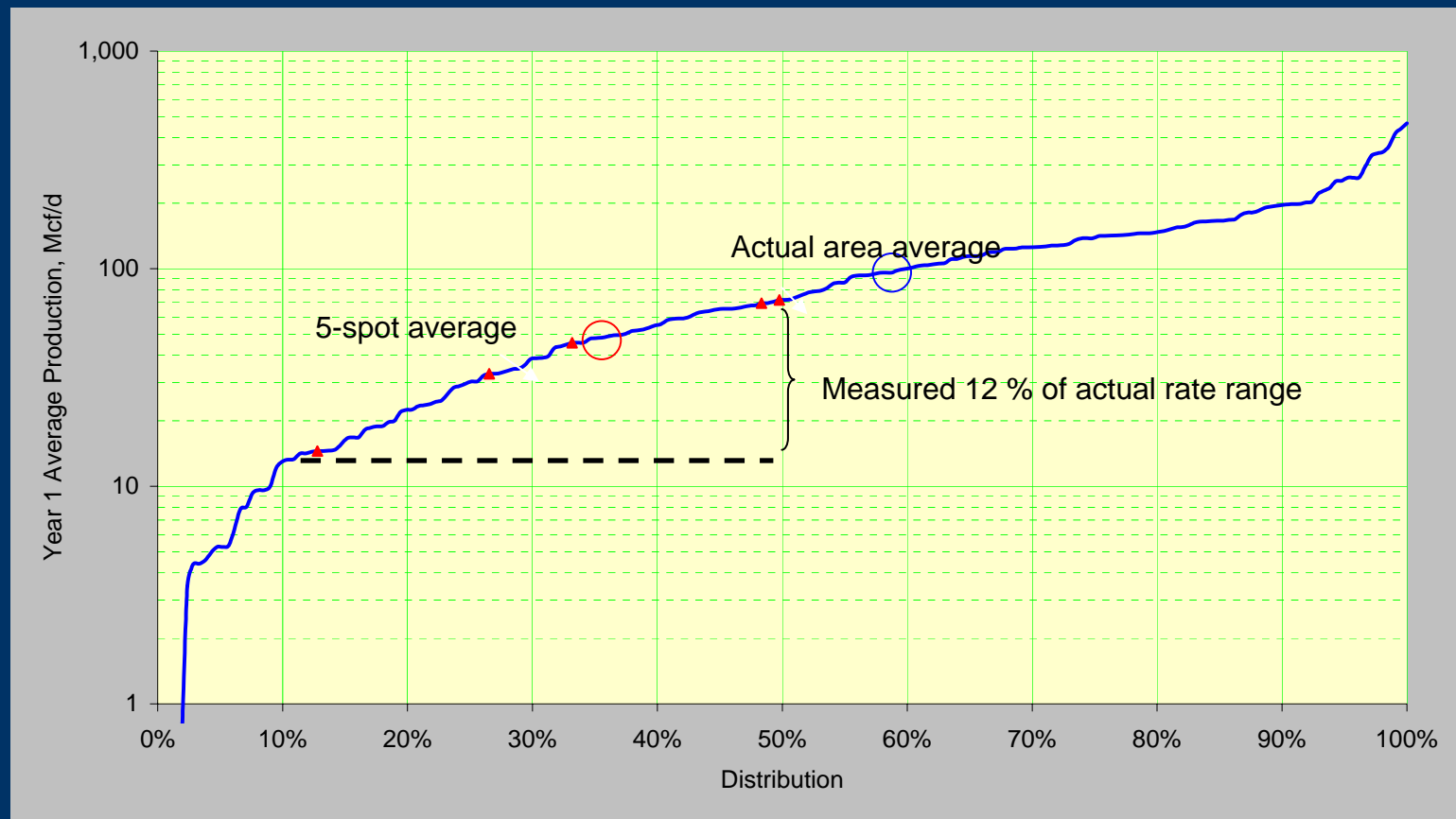
"Coalbed Gas Well Flow Performance Controls, Cedar Cove Area, Warrior Basin, U.S.A.," Sparks, D.P., Lambert, S.W., and McLendon, T.H., Paper 9376, *Proceedings 1993 International Coalbed Methane Symposium*, Tuscaloosa, AL, (May 17-21, 1993).

Example of Traditional Exploration- A Study in Hindsight



Comparing Pilot Test Result to Actual Area Average Production

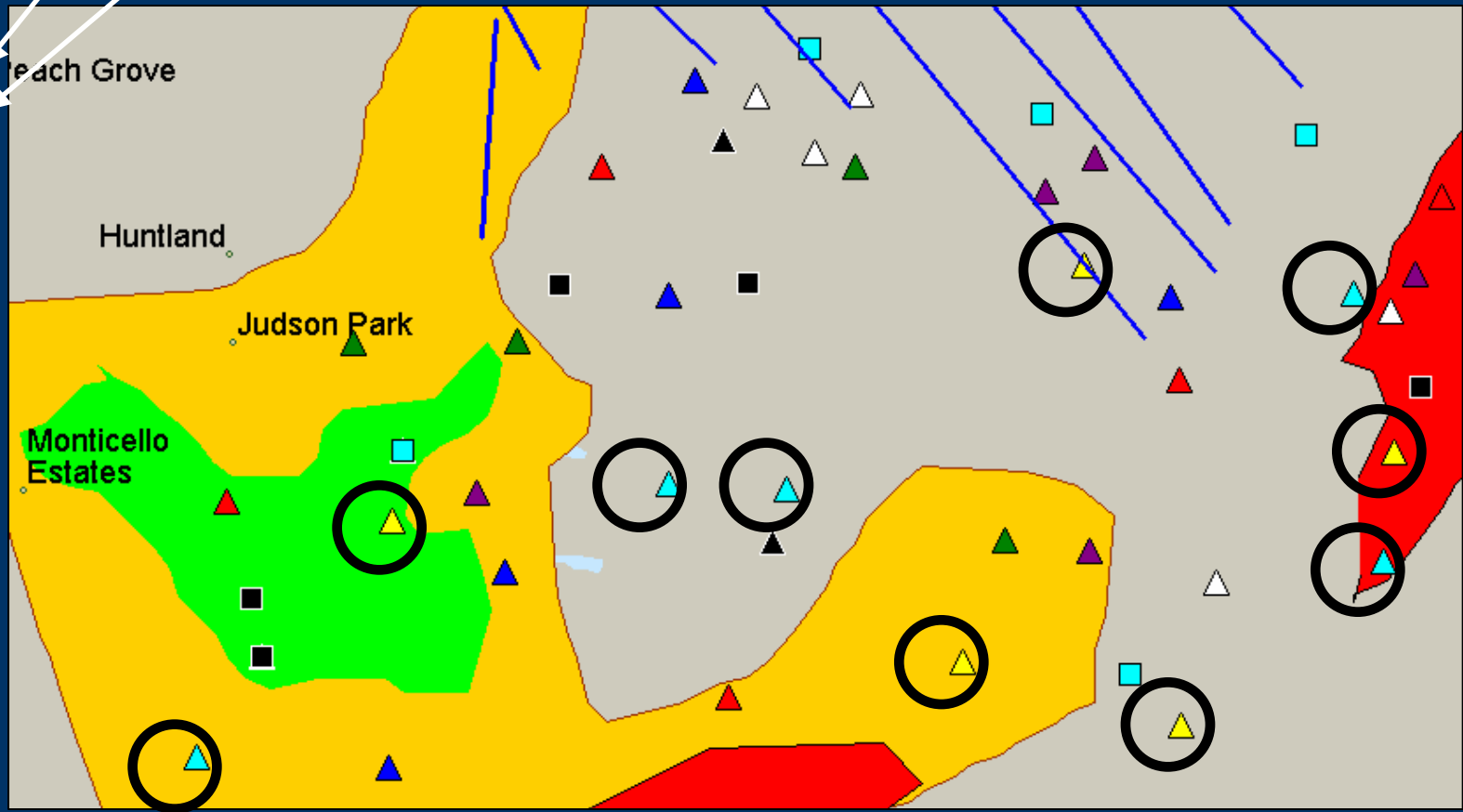
Would five randomly located test wells provide a more accurate result?



10 Sets of Randomly Selected Test Sites 5 Wells In Each Set

7% High (104 mcf/d)
58% Low (41 mcf/d)

- Run No. 1
- Run No. 2
- Run No. 3
- Run No. 4
- Run No. 5
- Run No. 6
- Run No. 7
- Run No. 8
- Run No. 9
- Run No. 10



Random Testing Compared to 5-Spot

Groups of Five Production test Wellsites Randomly Selected 10 Times		
	Average Production of Group, Mcf/d	Measured rate spread, %
Run No.1	99	49
Run No.2	104	38
Run No.3	41	29
Run No.4	89	30
Run No.5	73	26
Run No.6	68	22
Run No.7	65	31
Run No.8	109	38
Run No.9	78	37
Run No.10	66	23
5-spot	47	12
Actual	97	100

Non-Traditional Coalbed Methane Exploration Methods (Random Selection)

1. Evaluate available data to develop a “segmented” project model
 - Define, prioritize and select segment area(s) for exploration testing, utilizing the “resource, romance, and known circumstances”
2. Randomly select a number of core/strat test sites within each selected segment
 - Objective is to measure and analyze the largest variety of reservoir conditions
3. Within each recognized remaining qualified segment, randomly select and complete a number of pilot production test wells
 - Reservoir analysis applications do not require “5-spots”
 - Evaluate and compare results to analogous basin/field rate variability and averages
4. Proceed to develop project value or abandon

Conclusions

- ❑ Coalbed methane reservoirs are naturally fractured
 - Resource variability is generally regional
 - Flow variability is generally small scale and controlled by natural fracture (cleat and joint) permeability

- ❑ Statistical sampling models describe production distribution
 - Confidence and error estimates can be used to identify minimum exploration requirements but generally require large numbers of wells

- ❑ Non-traditional exploration models may reduce risk
 - Random test site selections within multiple project geologic “segments” may improve exploration guidance

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