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"Intelligent Wells"

A Realistic Vision for the Next 10 Years!

Younes Jalali

Schlumberger

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

Topics

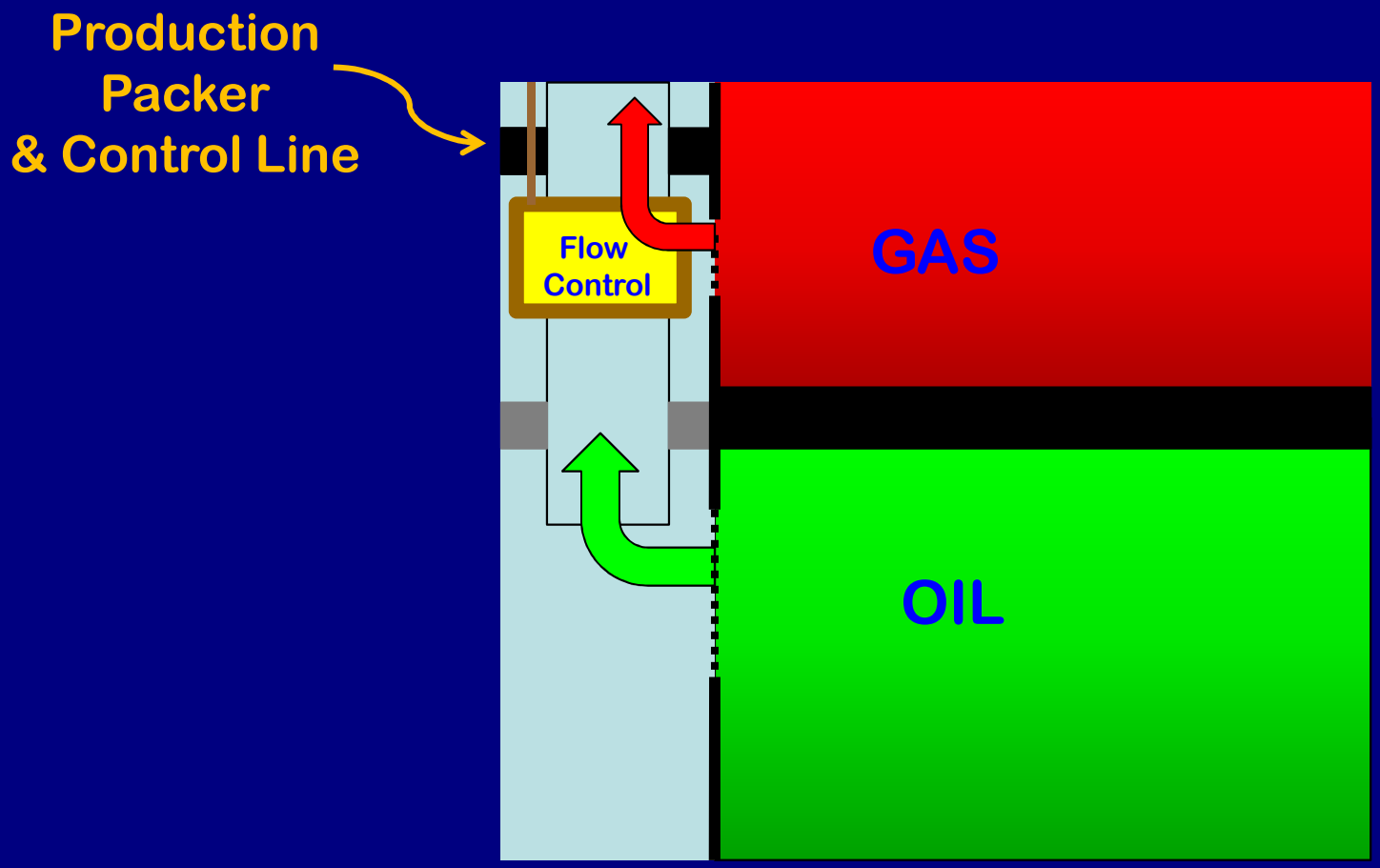
- i-wells, brief description
- 2 Scenarios for 2010-2020

i-wells -- Key Idea

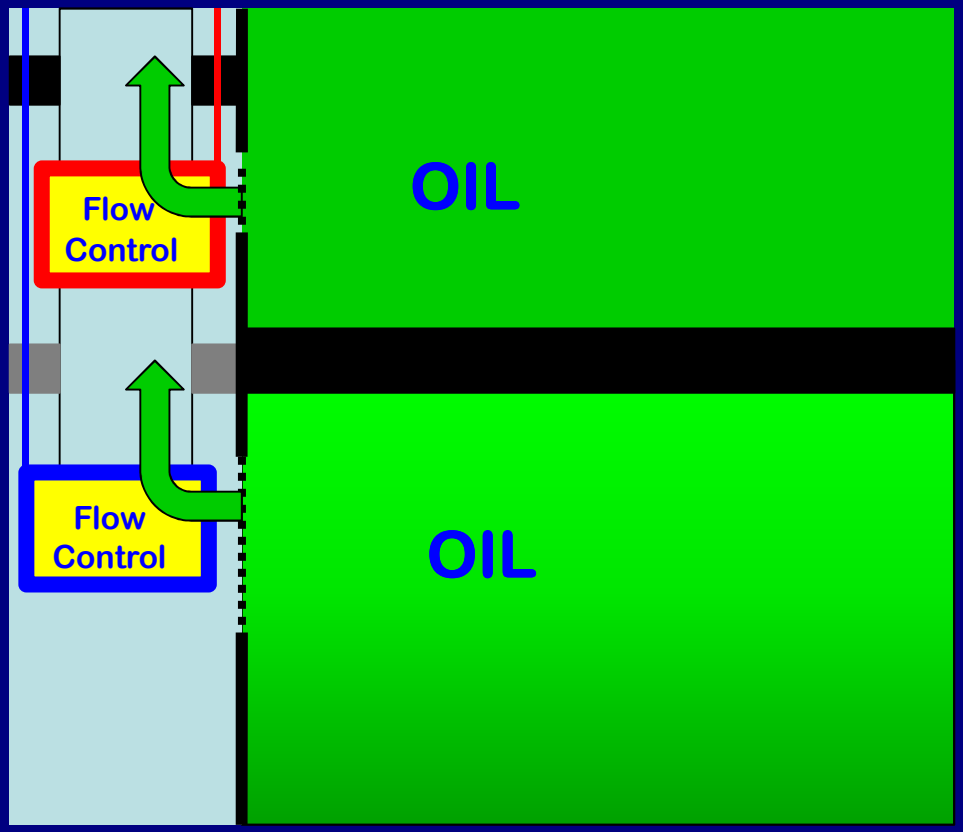
Flow control that is both selective and non-invasive is key to an i-well; monitoring is also important.

Selective Control	Non-Invasive Control
(Downhole @ Reservoir Level)	(Intervention w/o Borehole-Entry)

Control – Activation Type

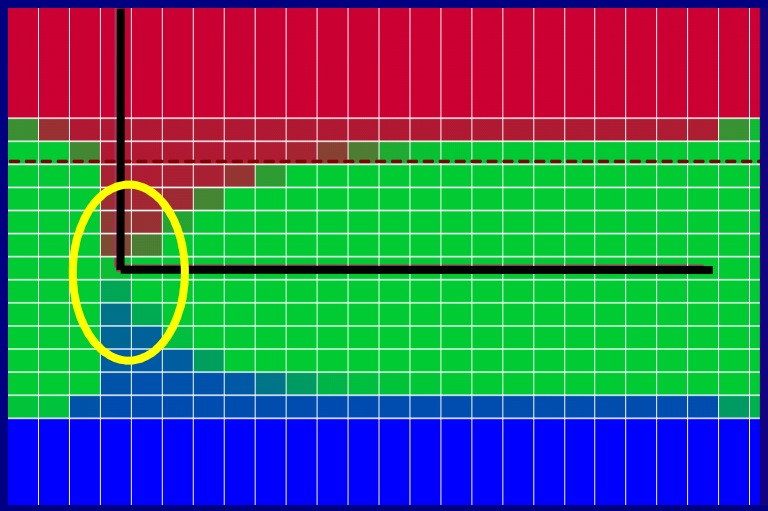


Control – Activation Type

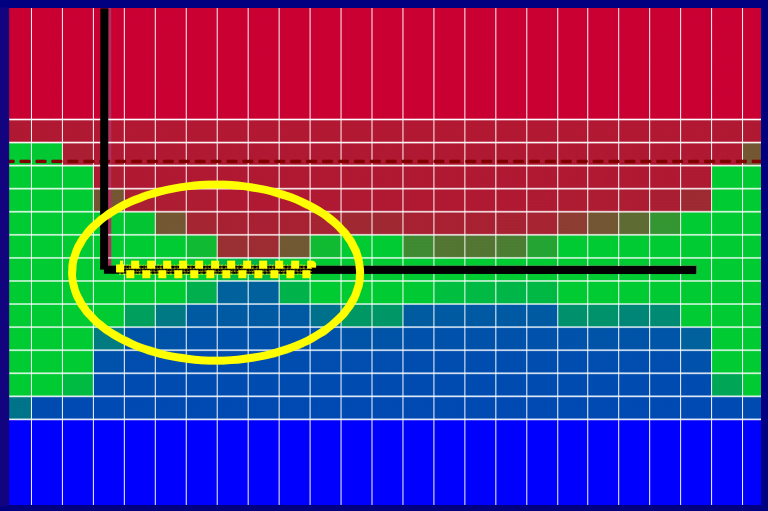


Control – Non-Activation Type

Liner Completion (no control)

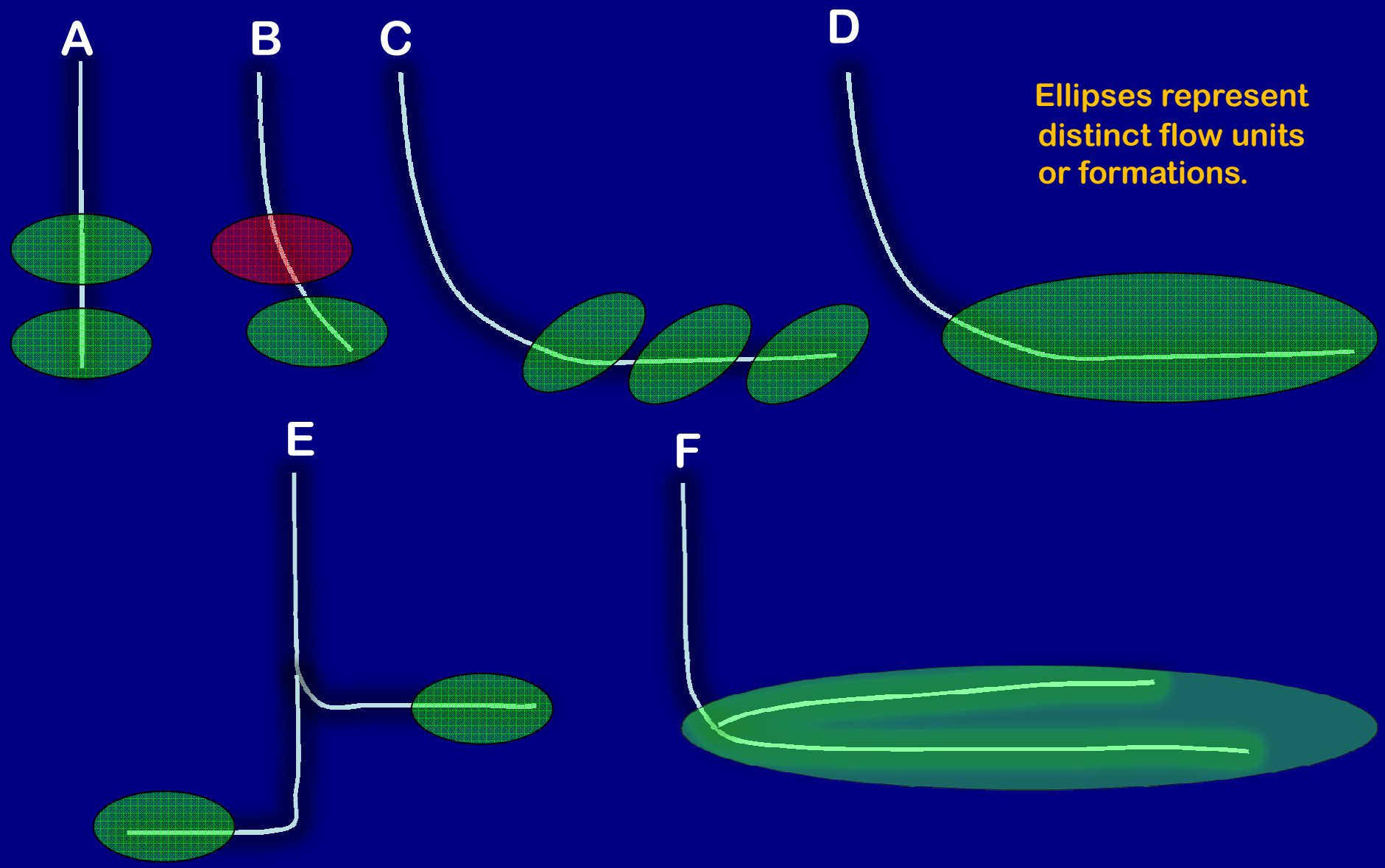


ICD* Completion (selective control)



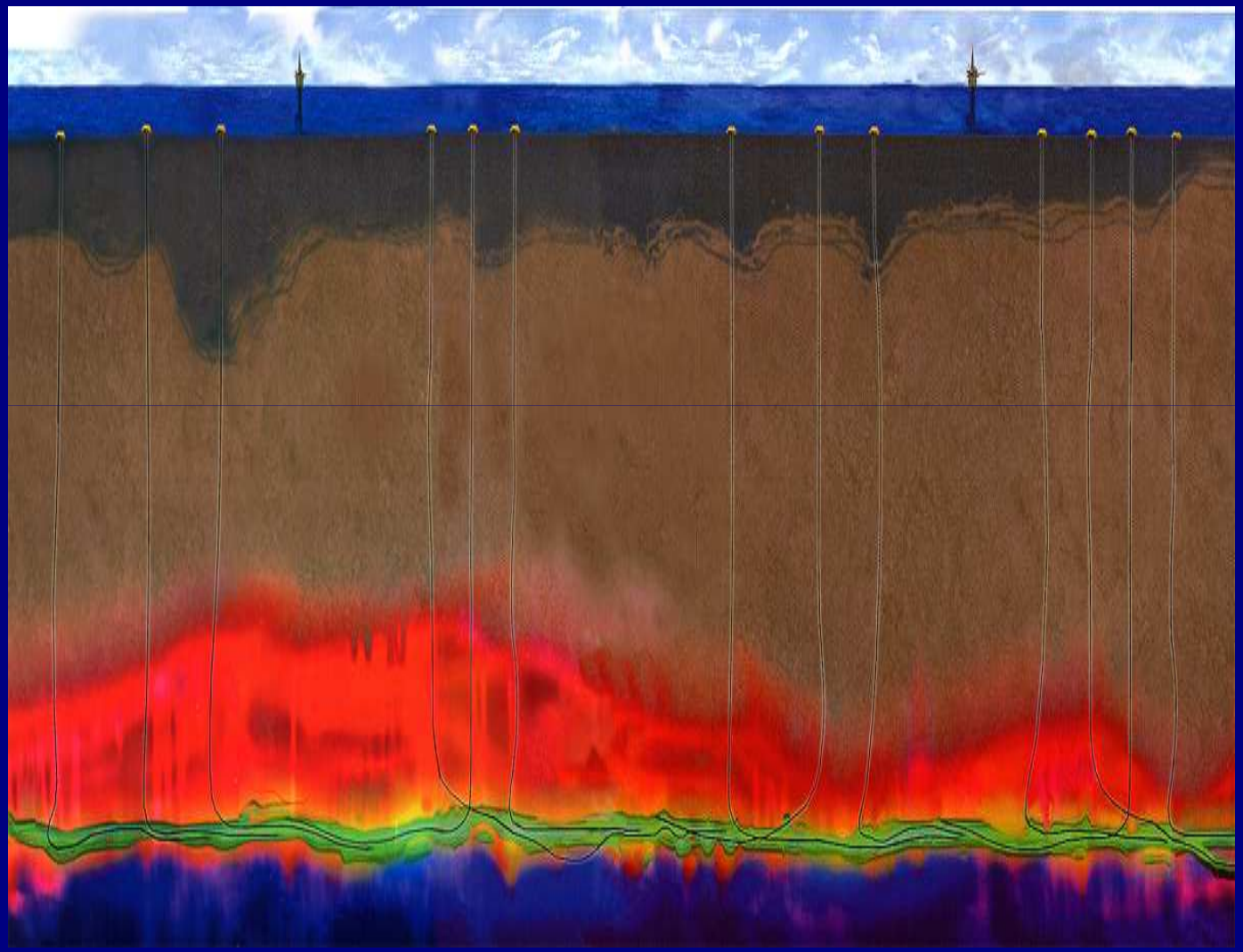
*ICD – inflow control device.

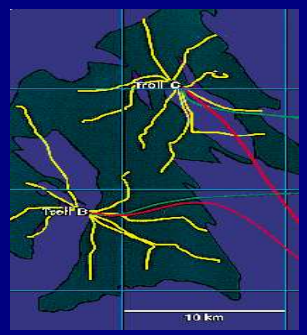
i-well Configurations…



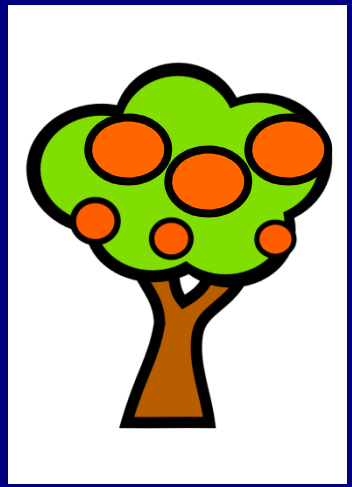
Ellipses represent distinct flow units or formations.

An Emblematic Field





2010-2020



A. “Low-Hanging” Scenario

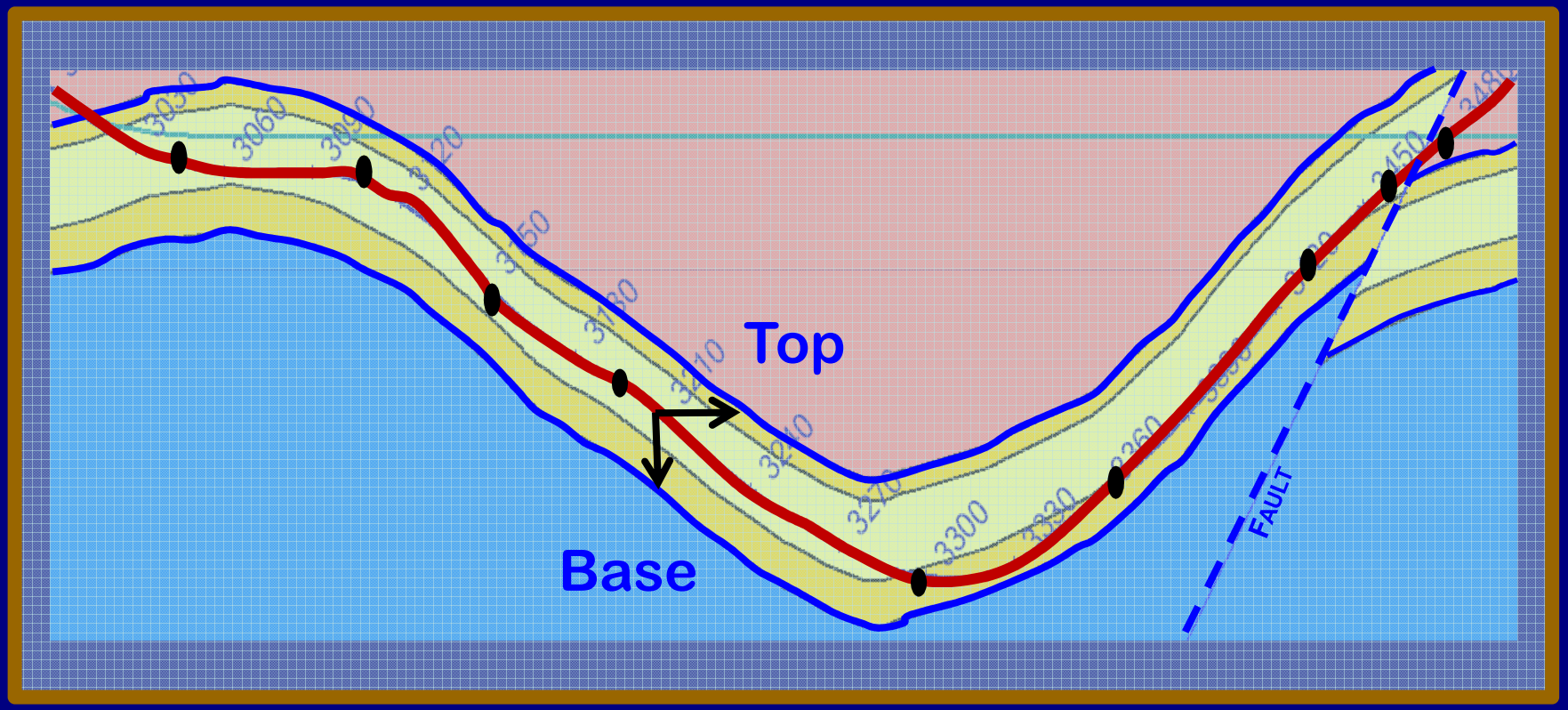
B. “High-Hanging” Scenario

Scenario A

- Within reach
- Already underway
- Focus on offshore & producers
  - Horizontals: exciting developments
  - Non-Horizontals: business as usual

Horizontal Drilling & Measurements

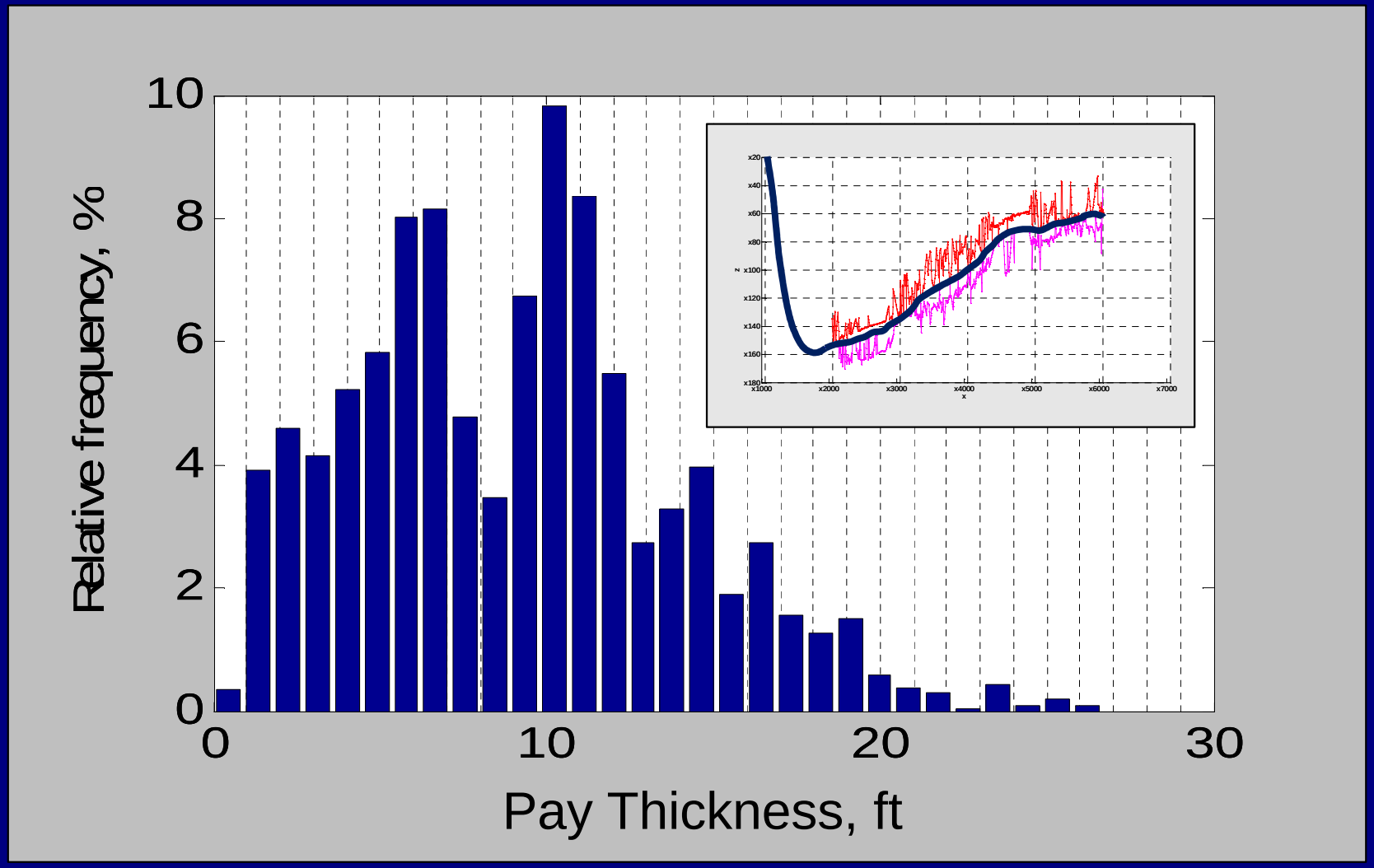
Boundary & Mobility Logs*



*DTBB – distance to bed boundary, based on directional deep resistivity measurements

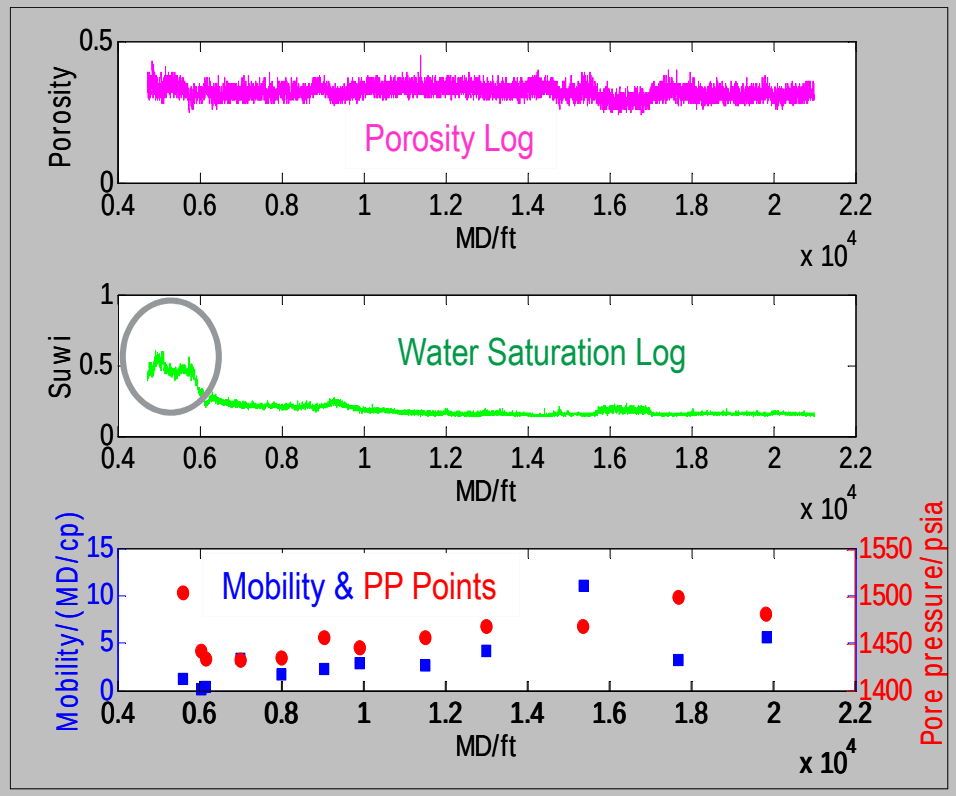
*FTWD – formation testing while drilling, spot measurements of pore pressure & mobility

Pay Thickness Estimation

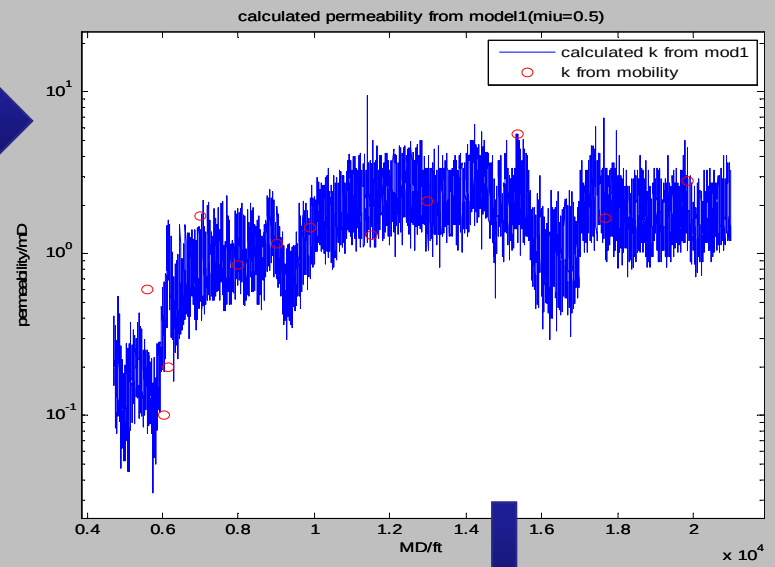


Permeability Estimation

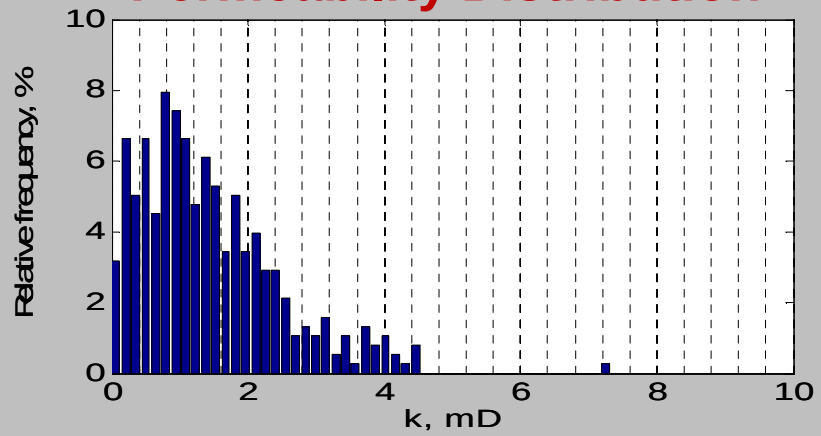
Petrophysics & Mobility Log



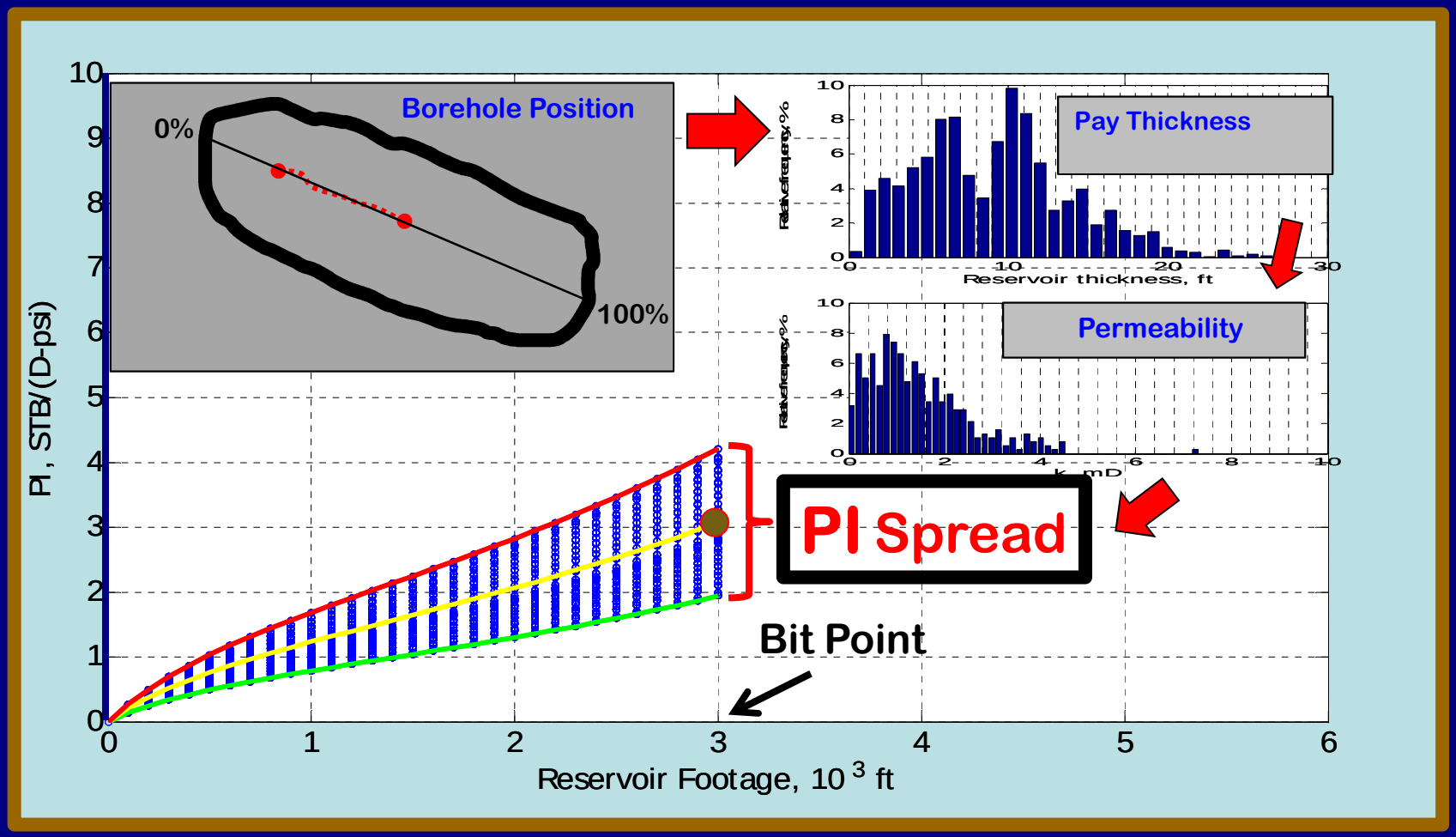
Inferred Permeability Log



Permeability Distribution

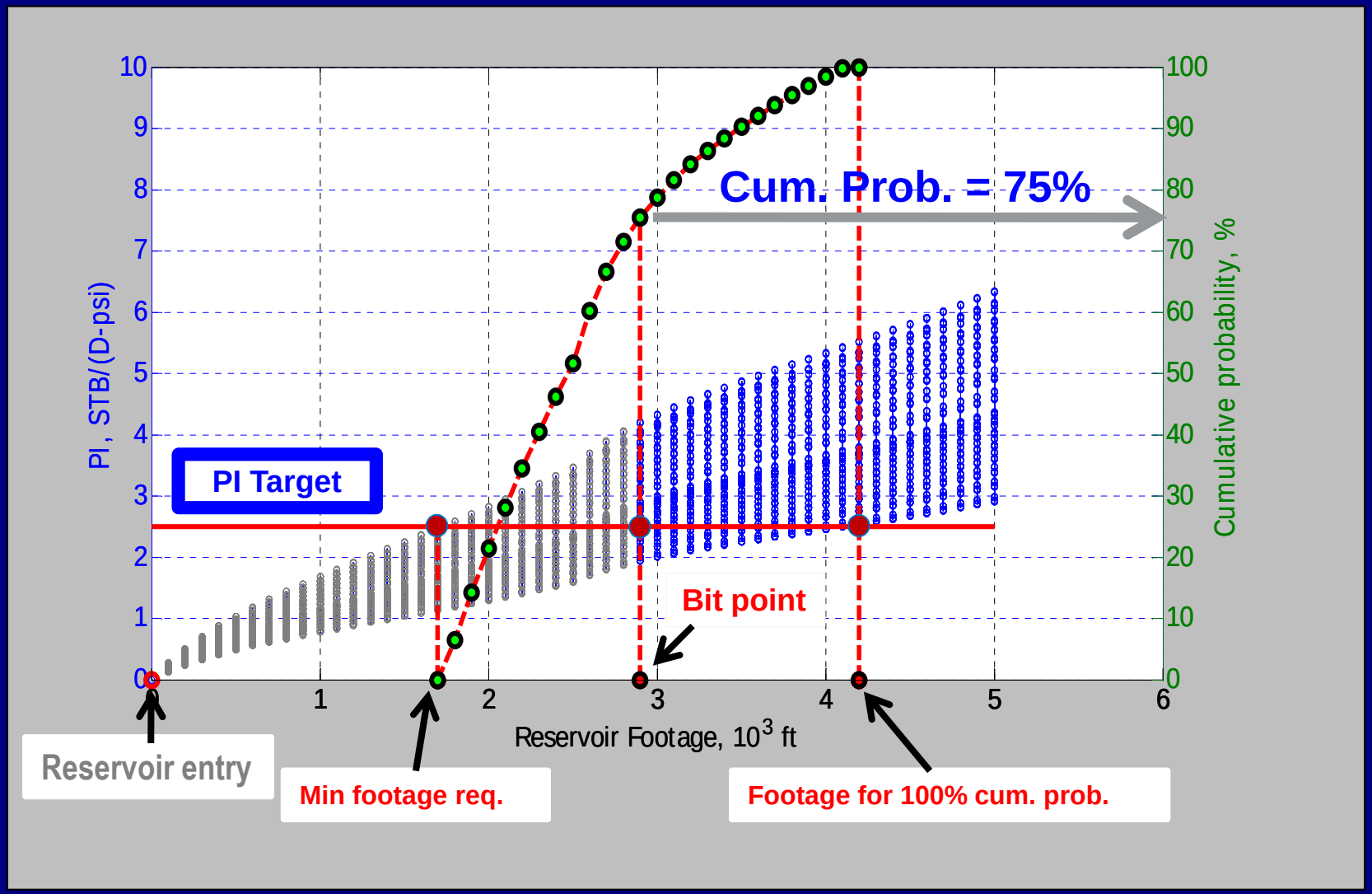


Productivity Estimation*



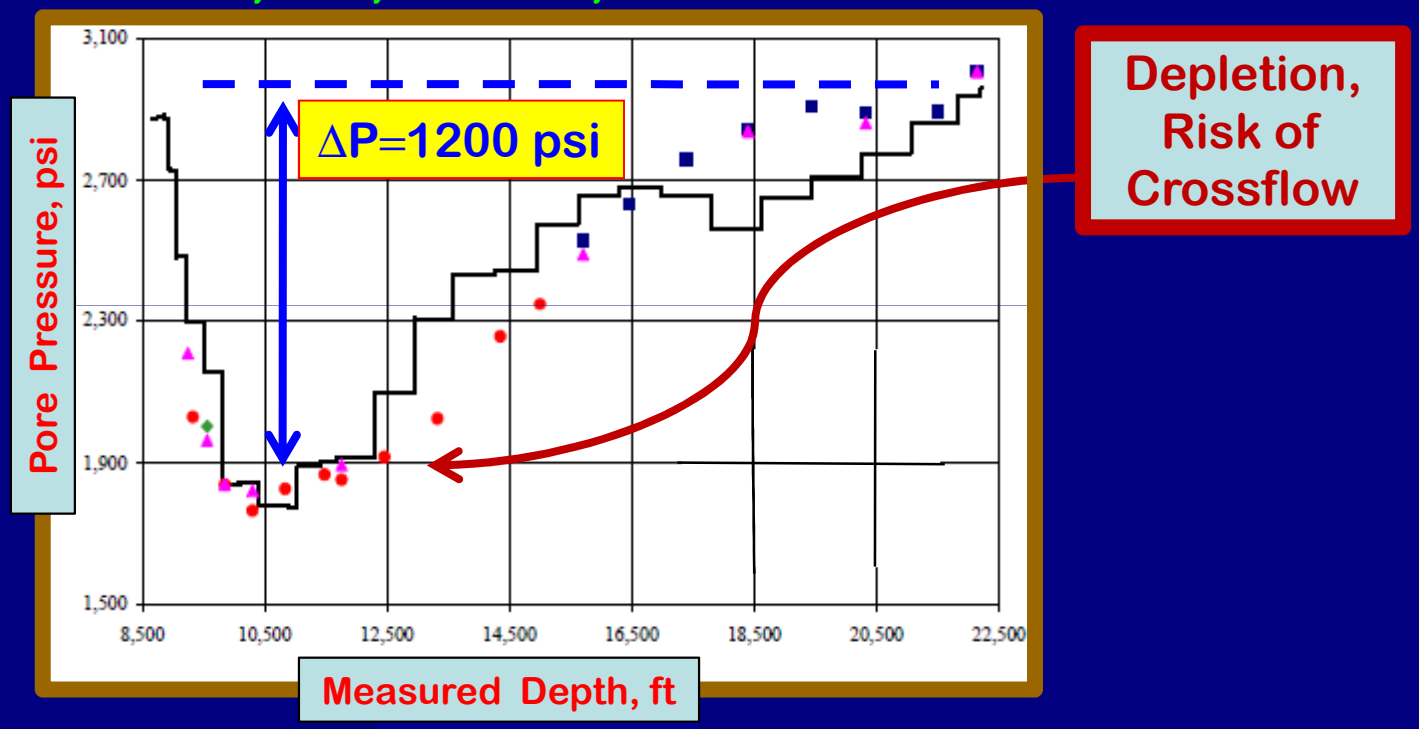
*Zhang et al (EAGE 9020) – Well Productivity Estimation during Drilling

Drilling Decisions



Completion Risks (1/3)

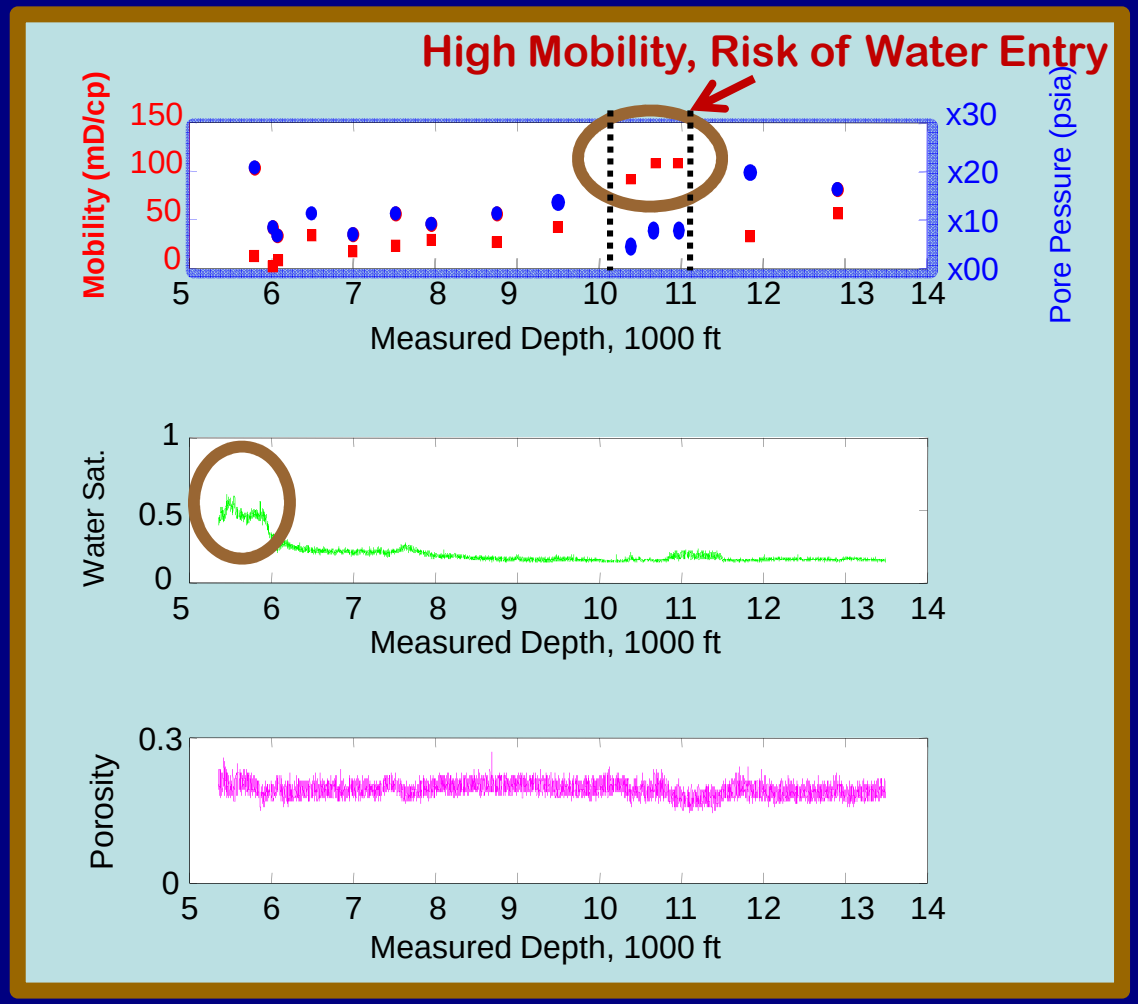
*pore pressure profile**



**Frank et al (SPE 87091)*

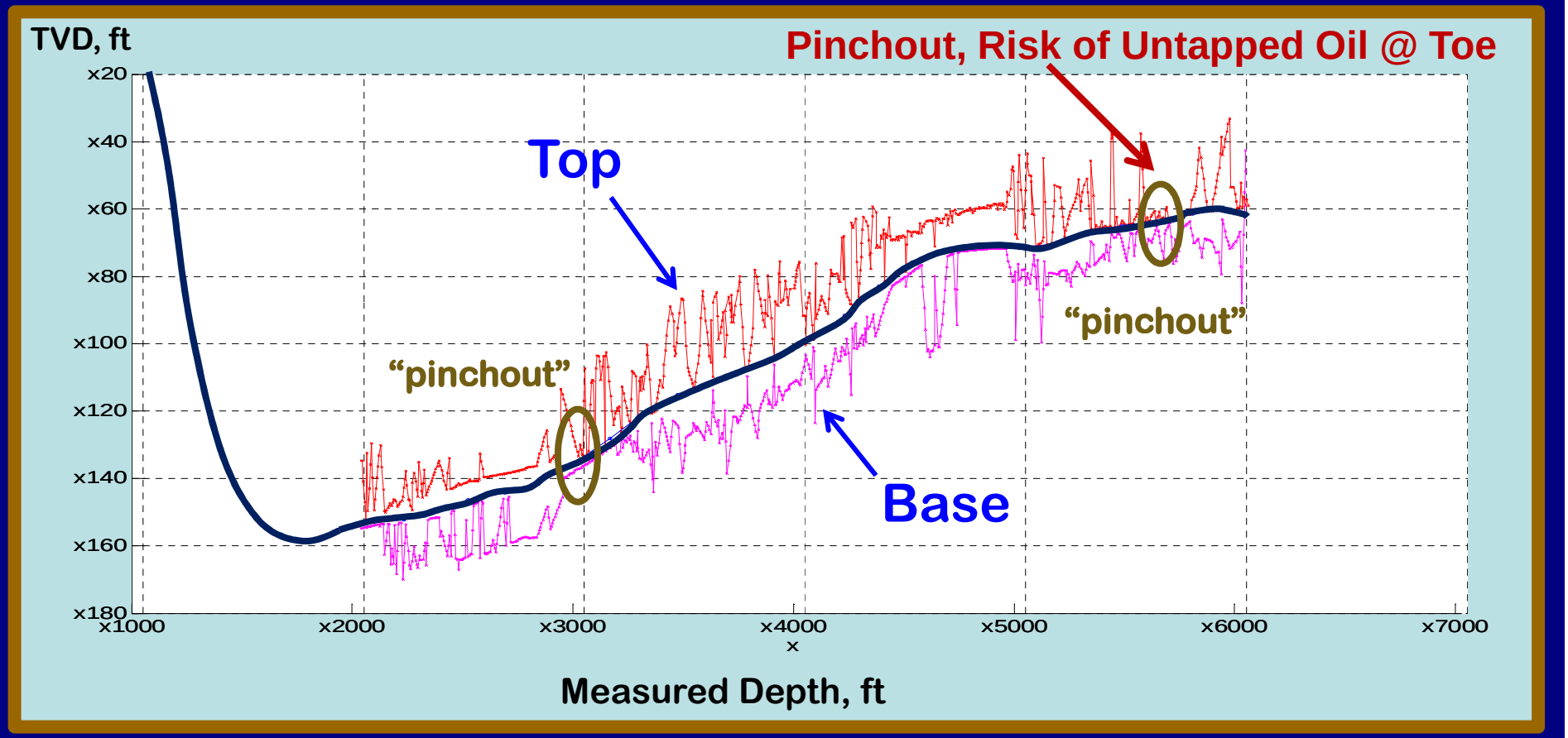
Completion Risks (2/3)

mobility profile

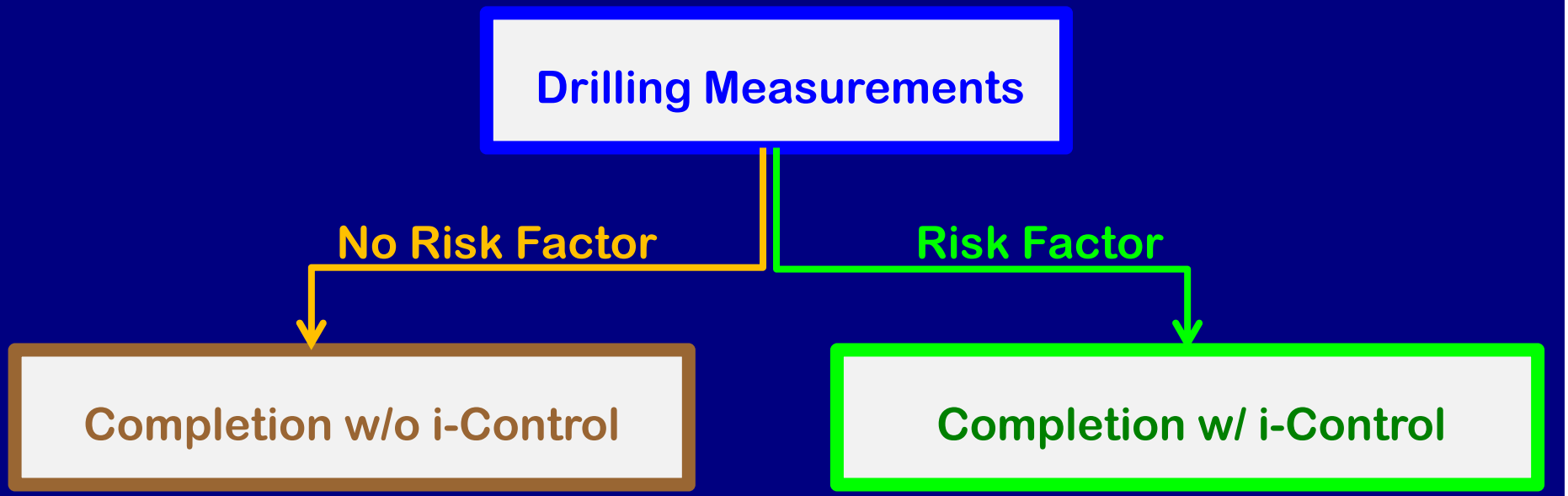


Completion Risks (3/3)

bed boundary profile



De-Risk the Completion



completion decisions during drilling, imperative!

De-Risk Platform

Domain Experts

Interactive Analysis Tools

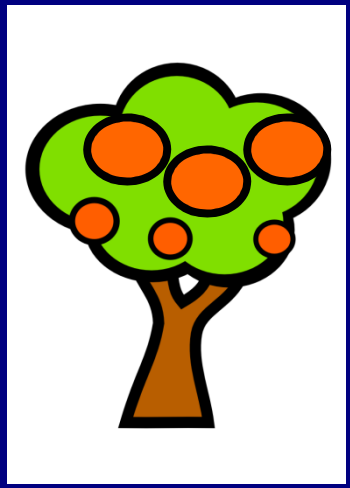
Connectivity Real-Time

Drilling Measurements

"Time-Critical Analysis"

De-Risk Drilling & Completion // Speed & Accuracy Key

Scenario B



- Harder to reach
- Need a good “tailwind”
- Tailwind inevitable, timing uncertain

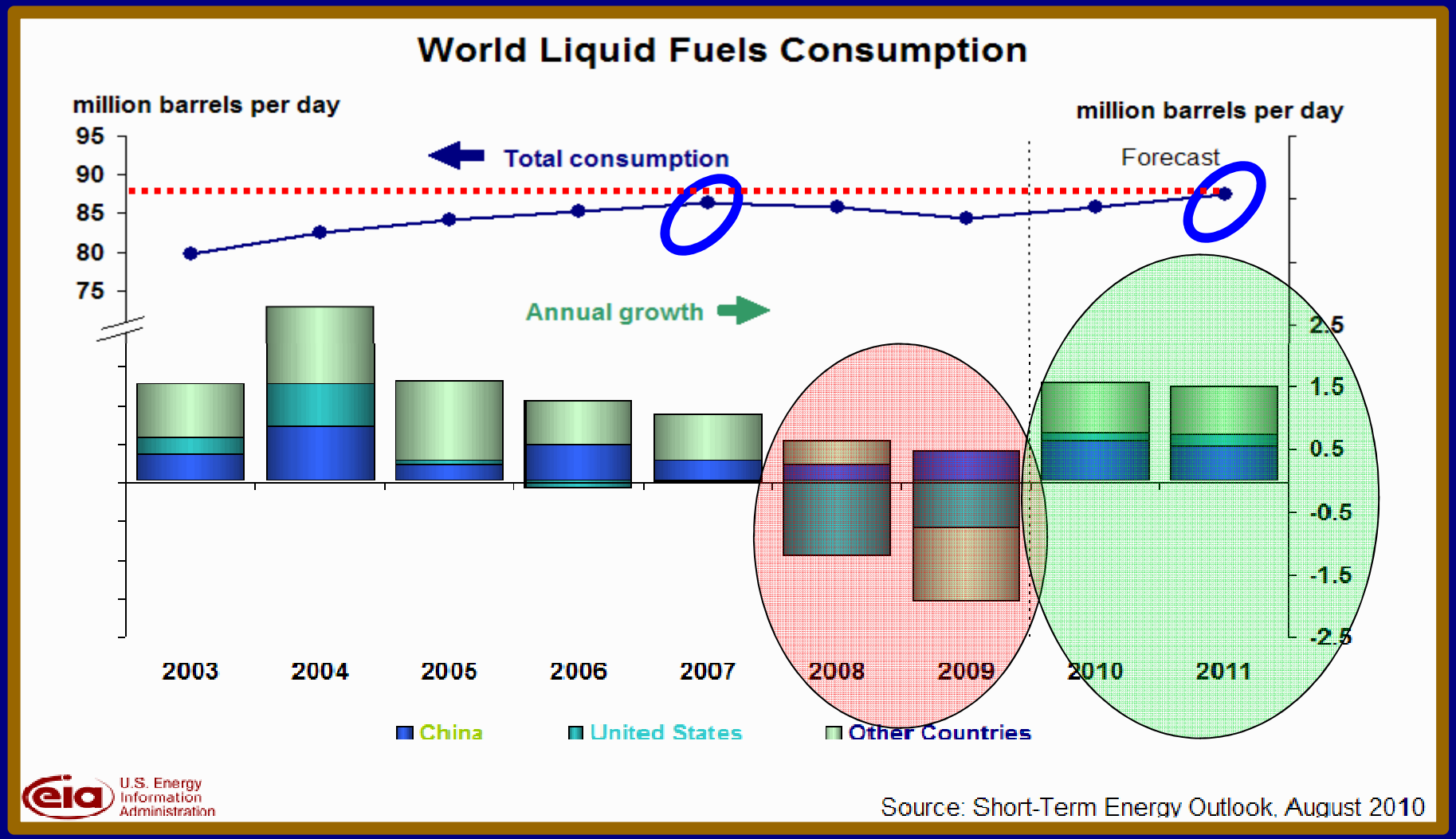
The Tailwind

- 2010 ~ 85 million bpd (current global oil demand)*
- 2020 ~ 95 million bpd (projected demand, OPEC Ref. Case)**
- Gap ~ 10 million bpd (old fields, new fields, heavy oil, condensates)
- i-well focus shifting to Giants & Injection

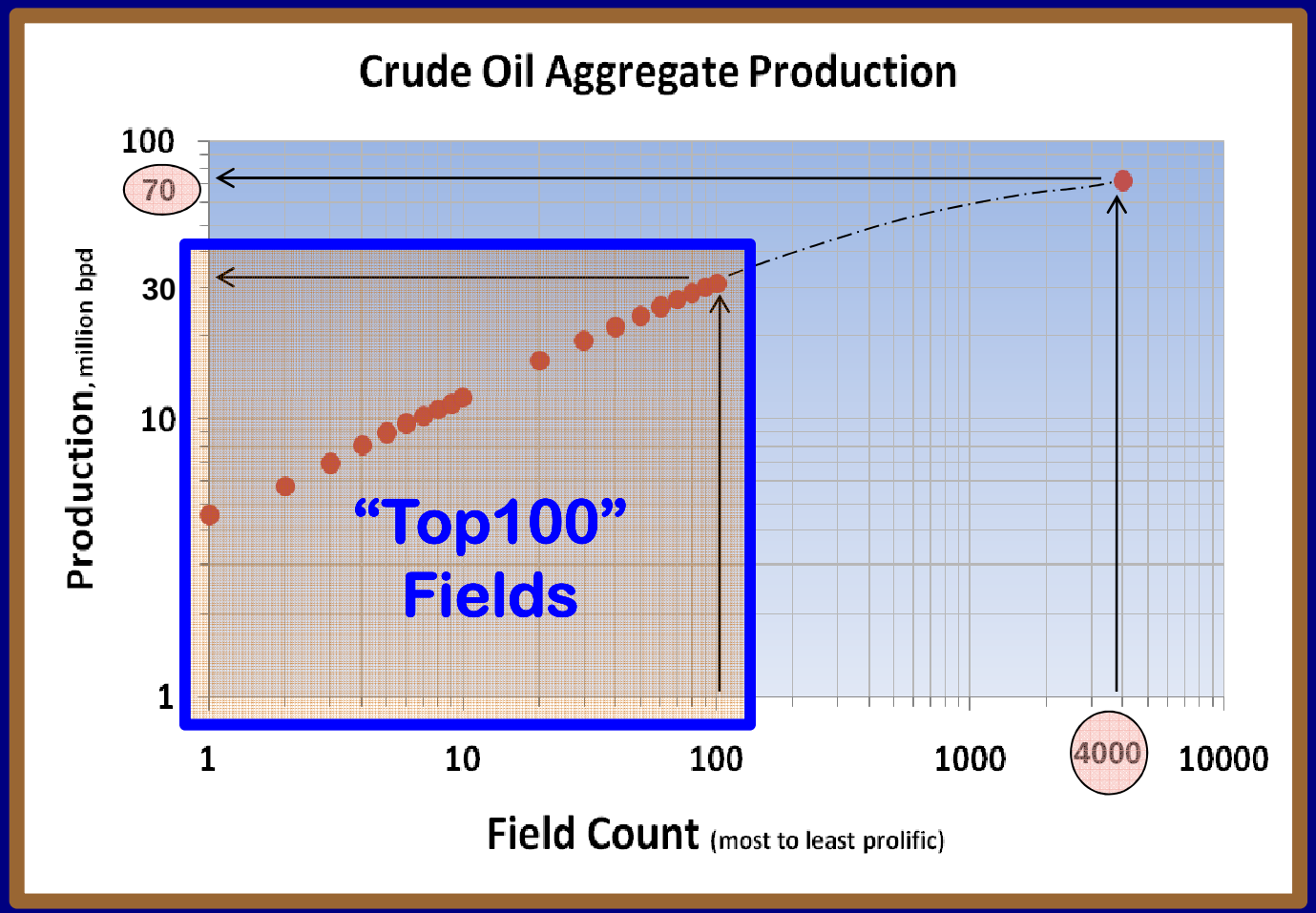
*US DOE / EIA (JPT, Aug. 2010, p.6)

**OPEC, World Oil Outlook, 2009, p. 159.

Early Indications

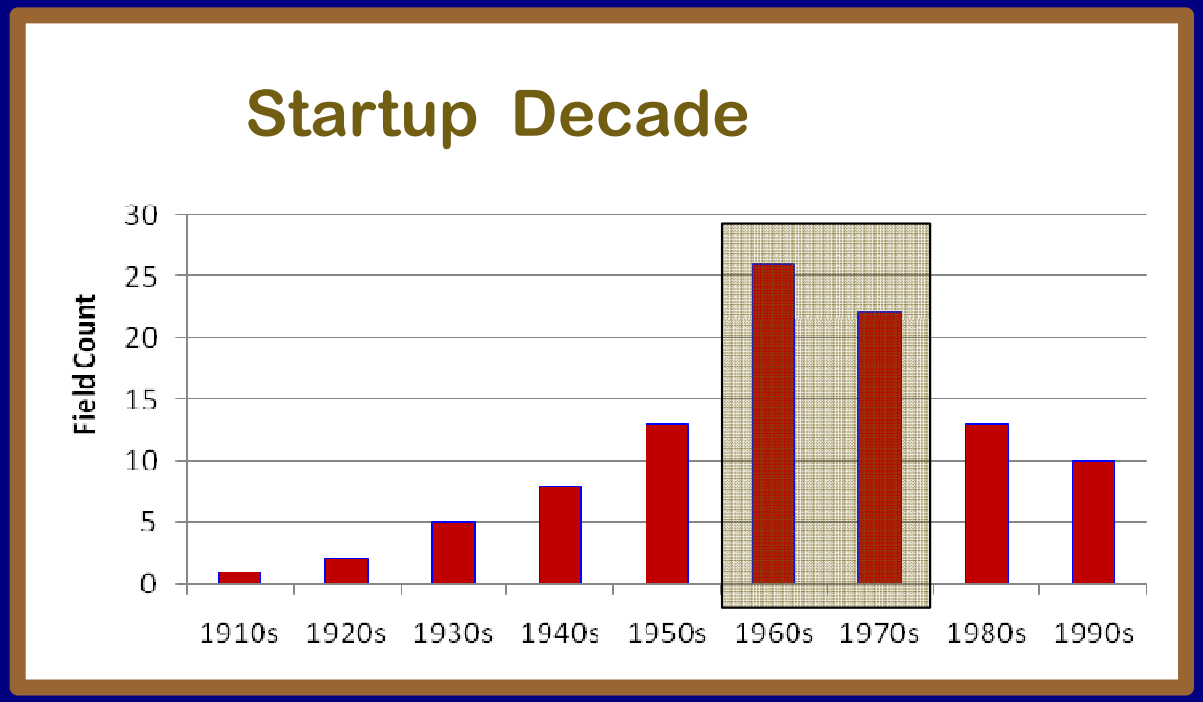


Importance of Top-100



Compiled from data in: "The World's Giant Oilfields", Yr 2000, M.R. Simmons.

Maturity of Top100

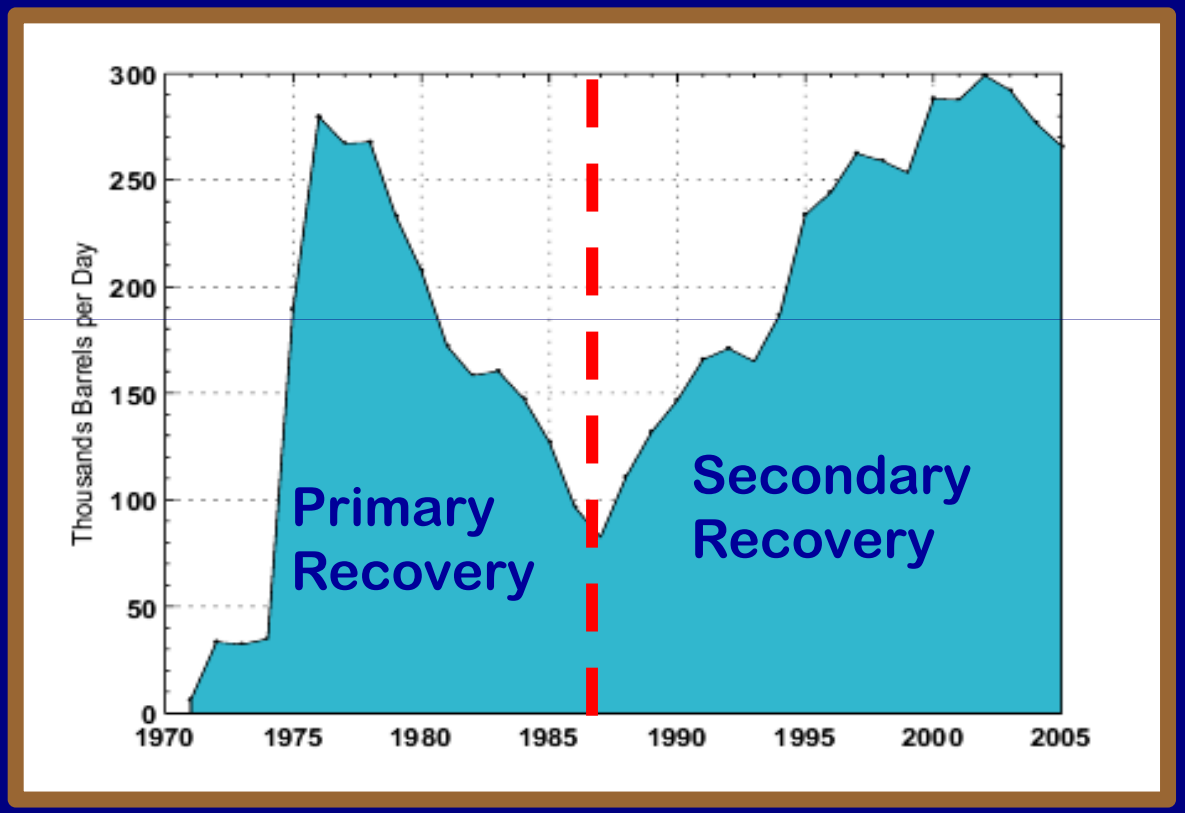


Compiled from data in: "The World's Giant Oilfields", Yr 2000, M.R. Simmons.

Top100 Field from 1940s

Compiled from data in "The World's Giant Oilfields", Yr 2000, M.R. Simmons + recent sources.

Top100 Field from 1970s

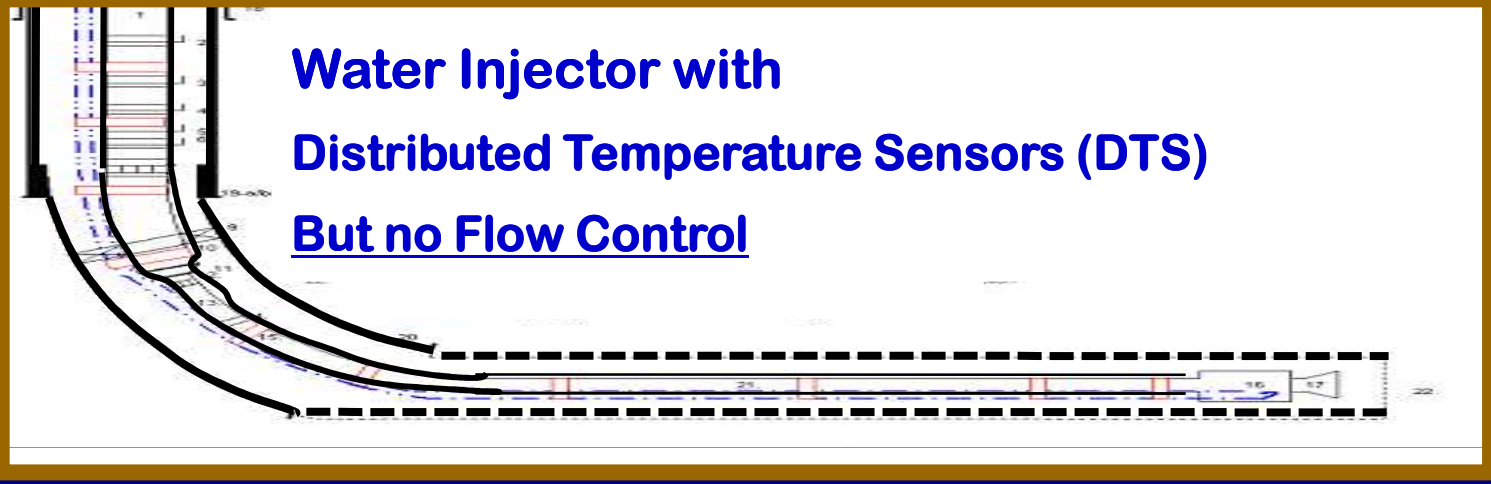


Ref: http://en.wikipedia.org/wiki/Ekofisk_oil_field

Criticality of Injection

- Hard to control, hard to monitor
- Achilles' heel of Res. Management
- Sweep efficiency – key metric
- Intelligent injection, a necessity

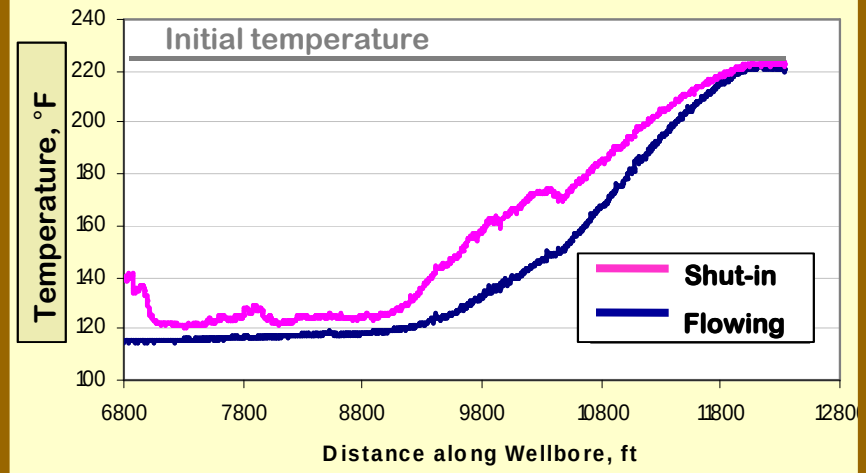
Injection – Single Layer

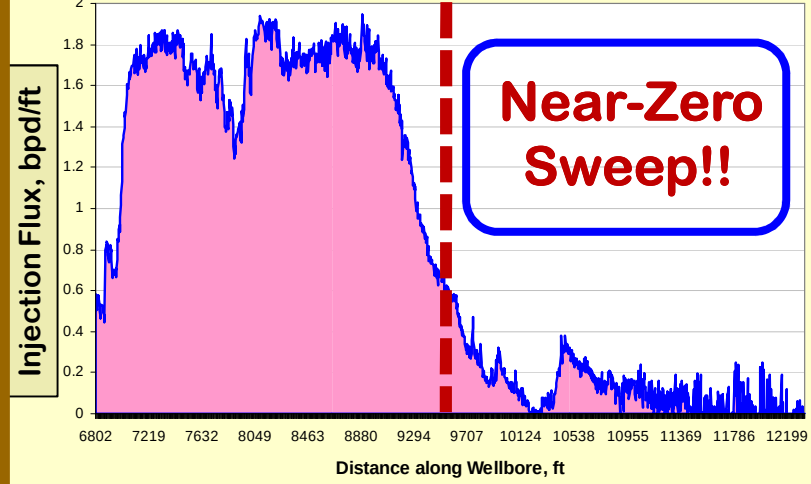


Water Injector with

Distributed Temperature Sensors (DTS)

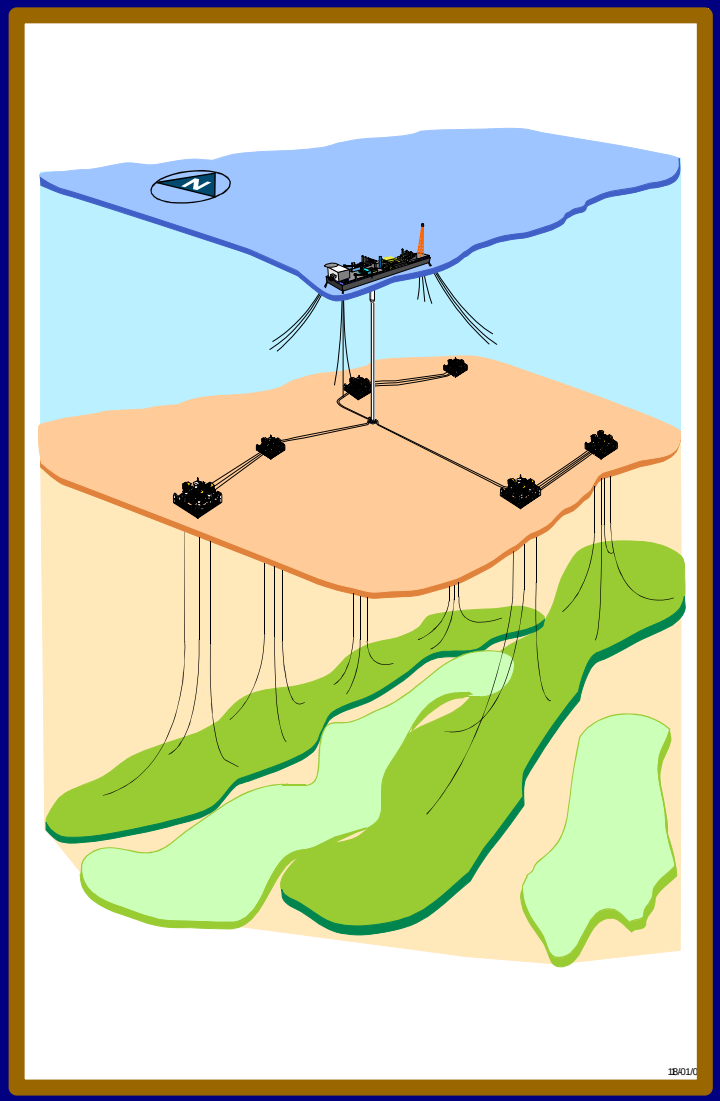
But no Flow Control

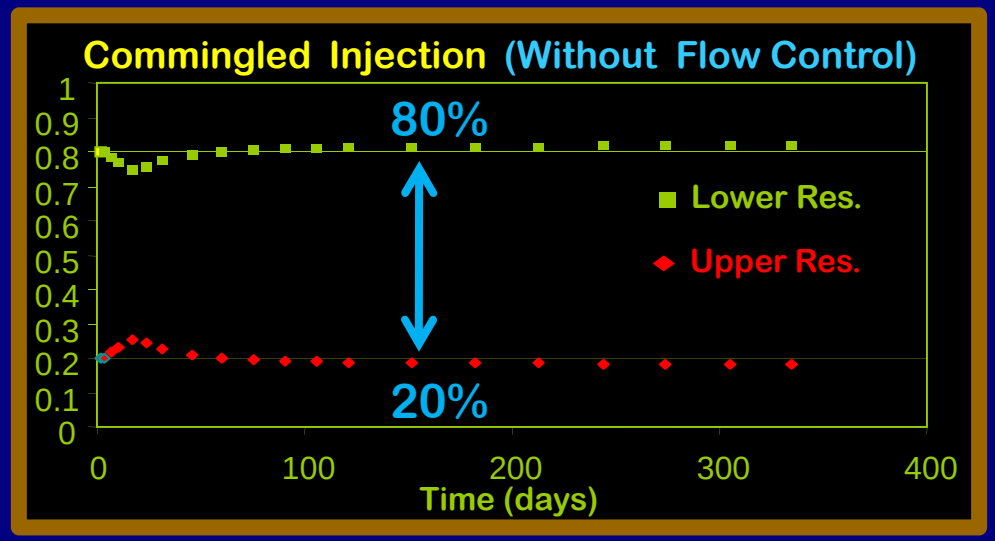


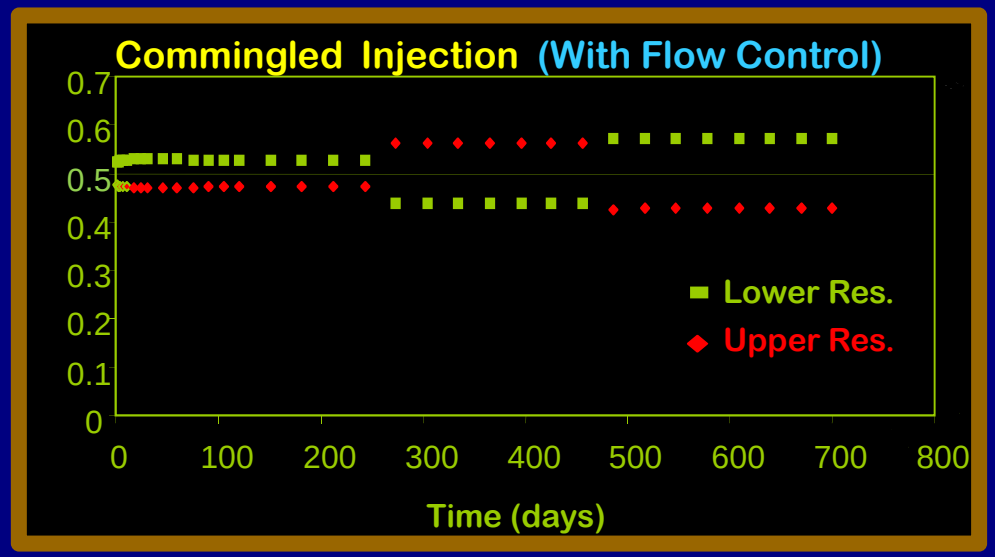


Bui et al (SPE 89924)

Injection – 2 Layers

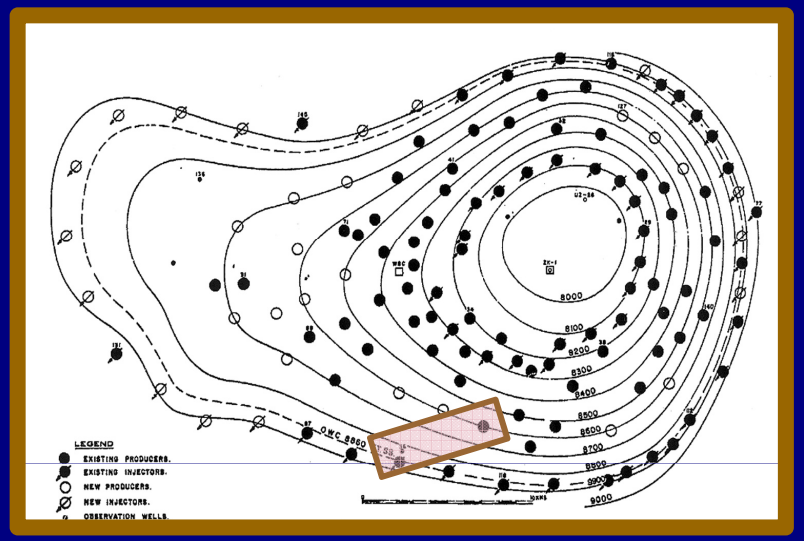


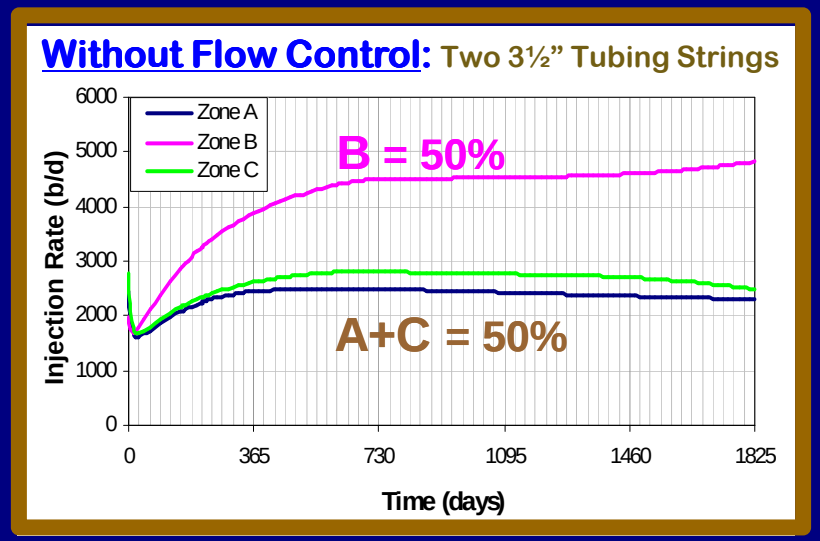


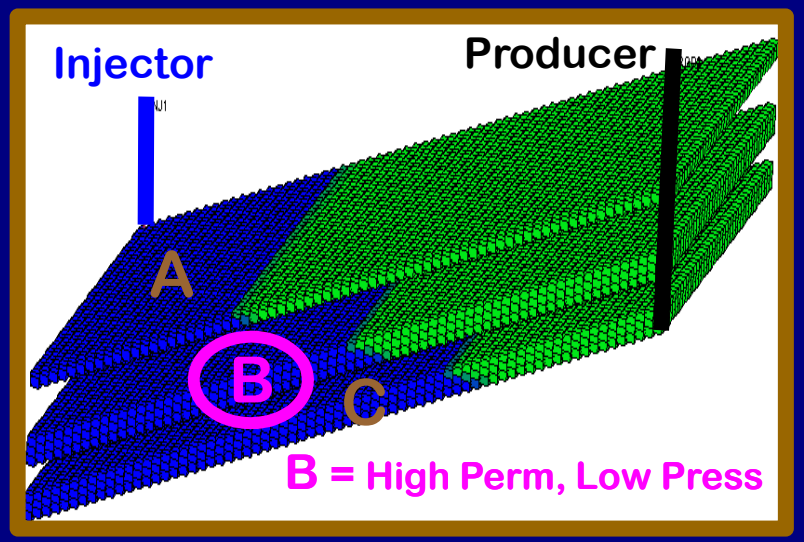


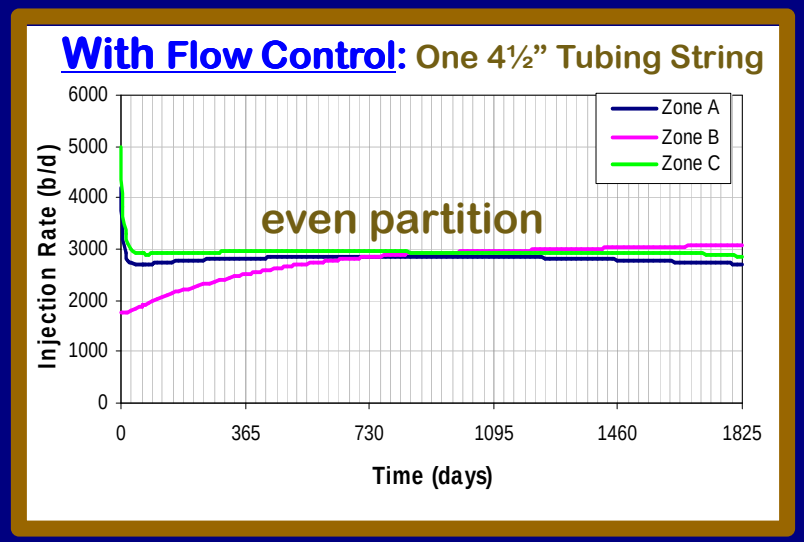
Gajraj et al (SPE 74392)

Injection – 3 Layers





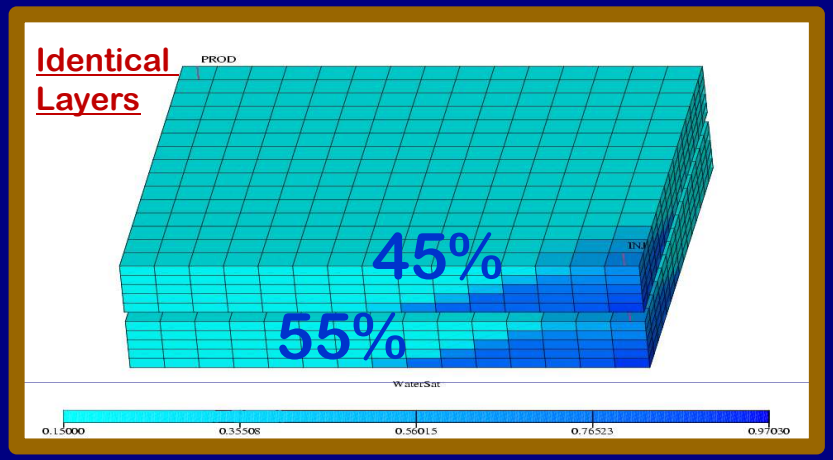




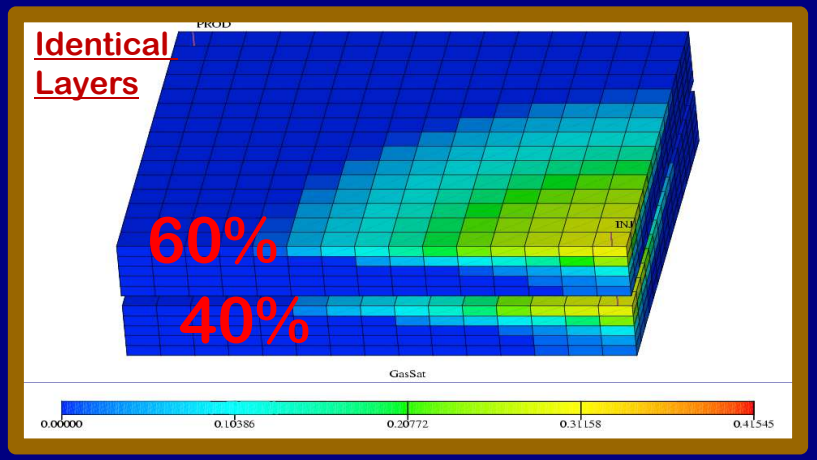
Gajraj et al (SPE 74392)

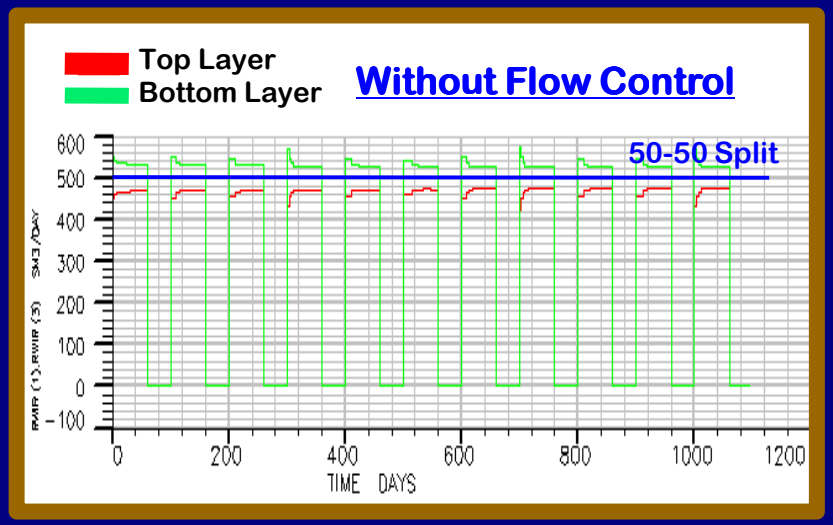
Injection – WAG

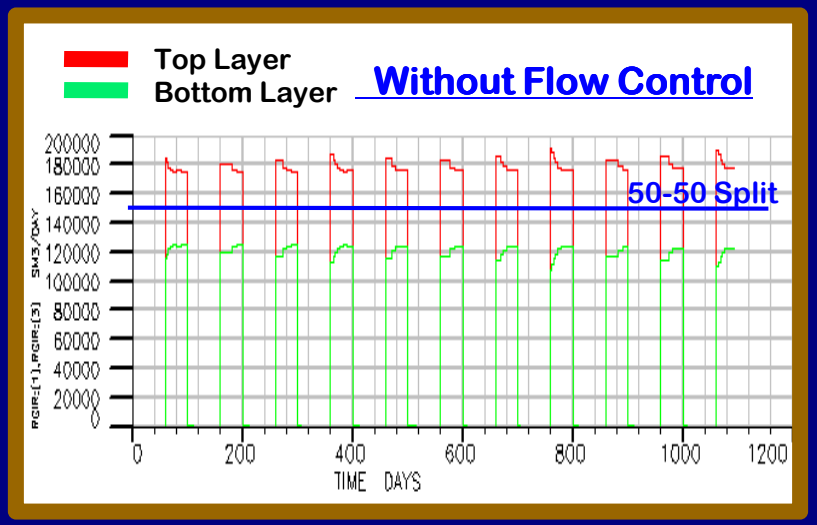
WATER Cycle (60 days)



GAS Cycle (40 days)







Gajraj et al (SPE 74392)

Final Remark

At this juncture, with 10^{+} yrs of i-well accomplishments & history, competitive advantage with i-wells can be derived only through 2 avenues (under-explored):

- Intelligent Drilling
- Intelligent Injection

Acknowledgements

- My team members
- Our management
- Our clients
- SPE, DL committee