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Distinguished Lecturer Program

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# Lunskoye Big Bore Gas Wells - Maximising Gas, Minimising Sand

**Mike Gunningham**
**Sakhalin Energy Investment Company**

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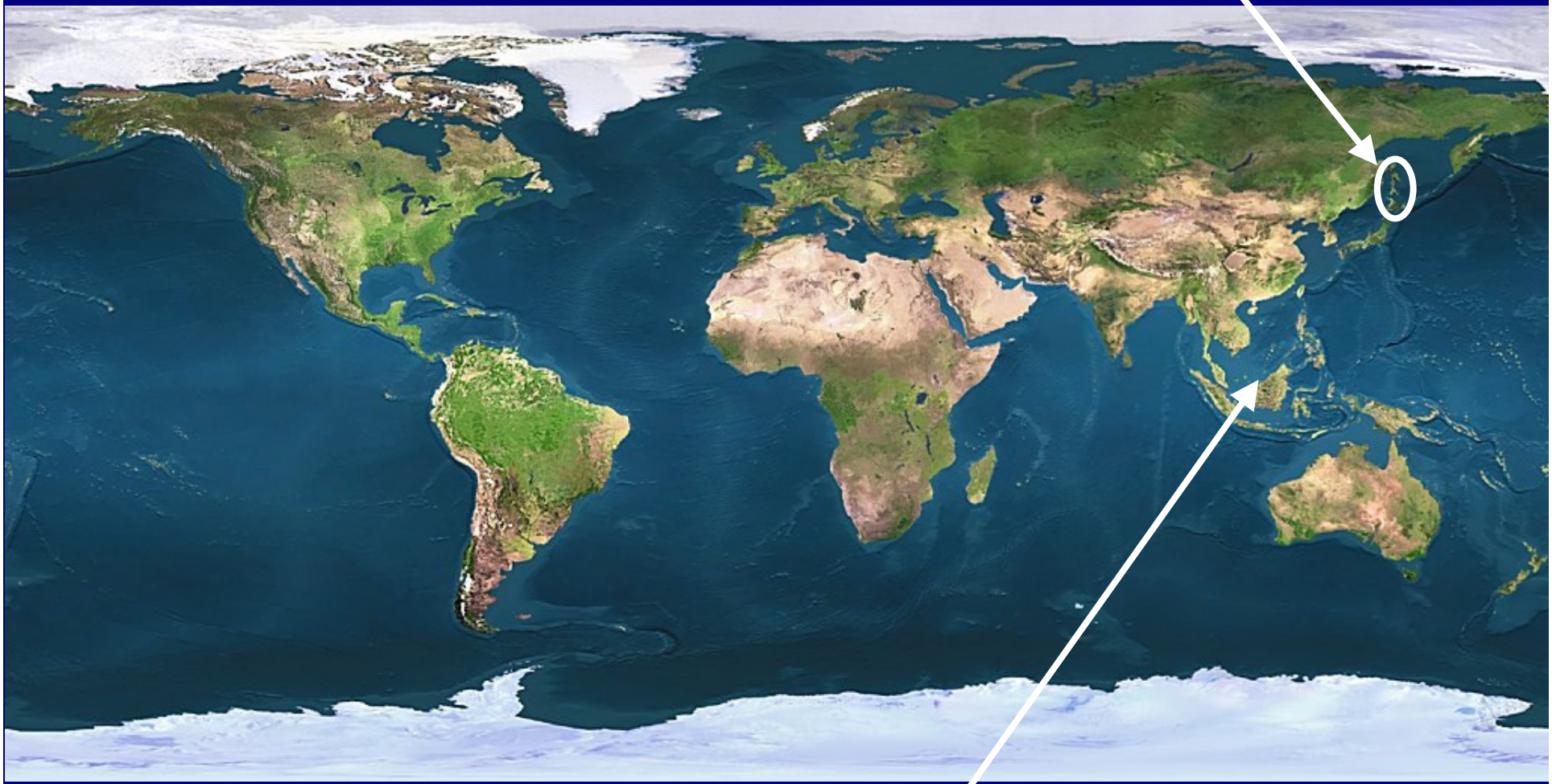
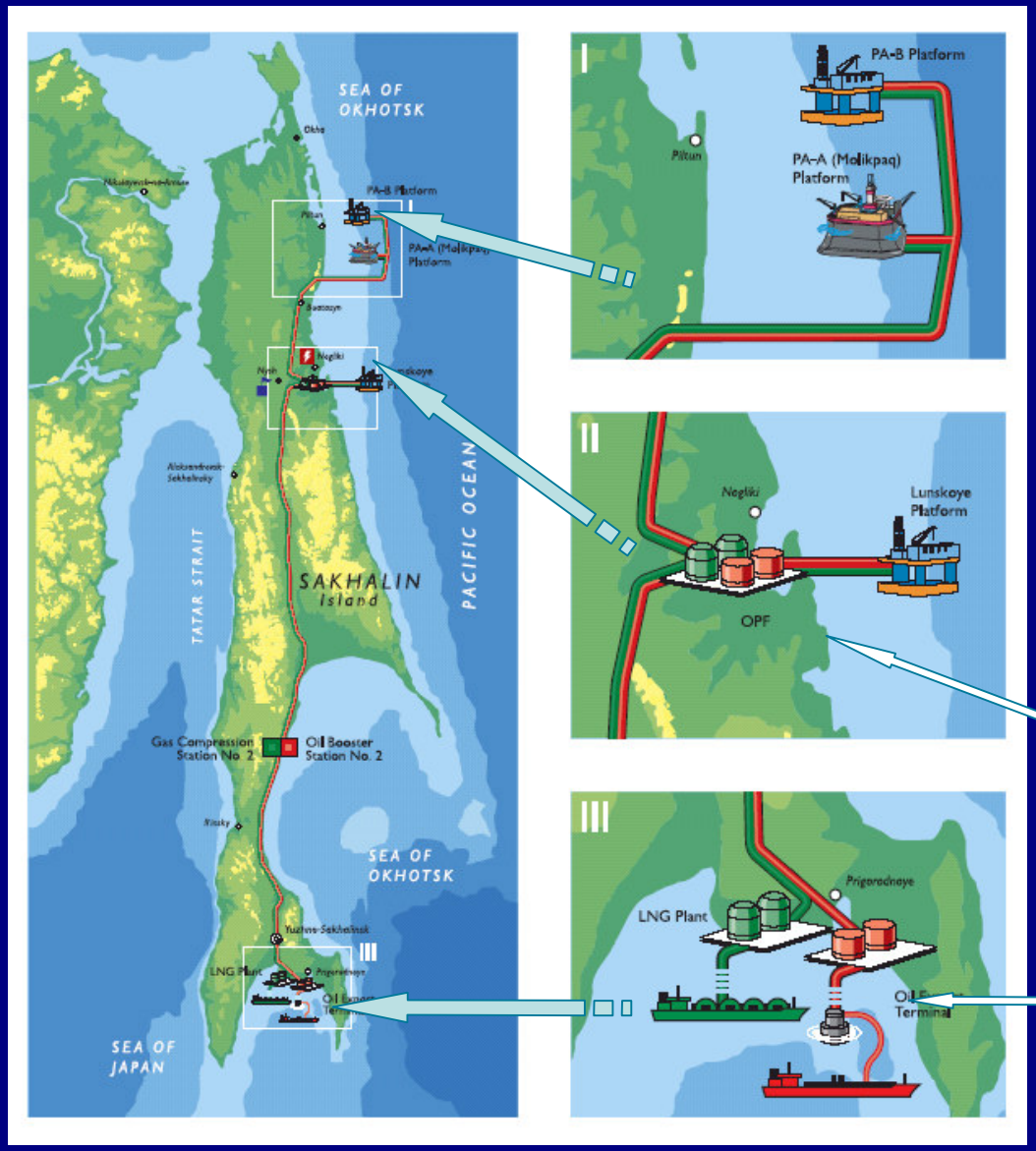
# Presentation Overview

- Introduction Sakhalin II Project
- Lunskoye Field Overview
- Overview of Original Completion Design
- New Sandface Completion Selection
- New Completion Design
- Quantitative Risk Assessment and Sand Management Plan
- Conclusions

# Where is Sakhalin?



# Sakhalin II Development




- Piltun B platform (70k BOPD)
- Astokh year round production (70k BOPD).
- Lunskoye A platform (1800 MMscf/d & 45k BCPD).
- Onshore processing facility.
- Oil and gas pipelines.
- LNG plant (9.6 MMTPA) & Oil Export Terminal.

# A Mega-Project in a Frontier Environment

**Every Aspect is HUGE! .. $22 billion**

**2 New Platforms**

**20,000+ People,**
**60x10$^{6}$ hrs p.a.**

**800km Oil & Gas Pipelines**

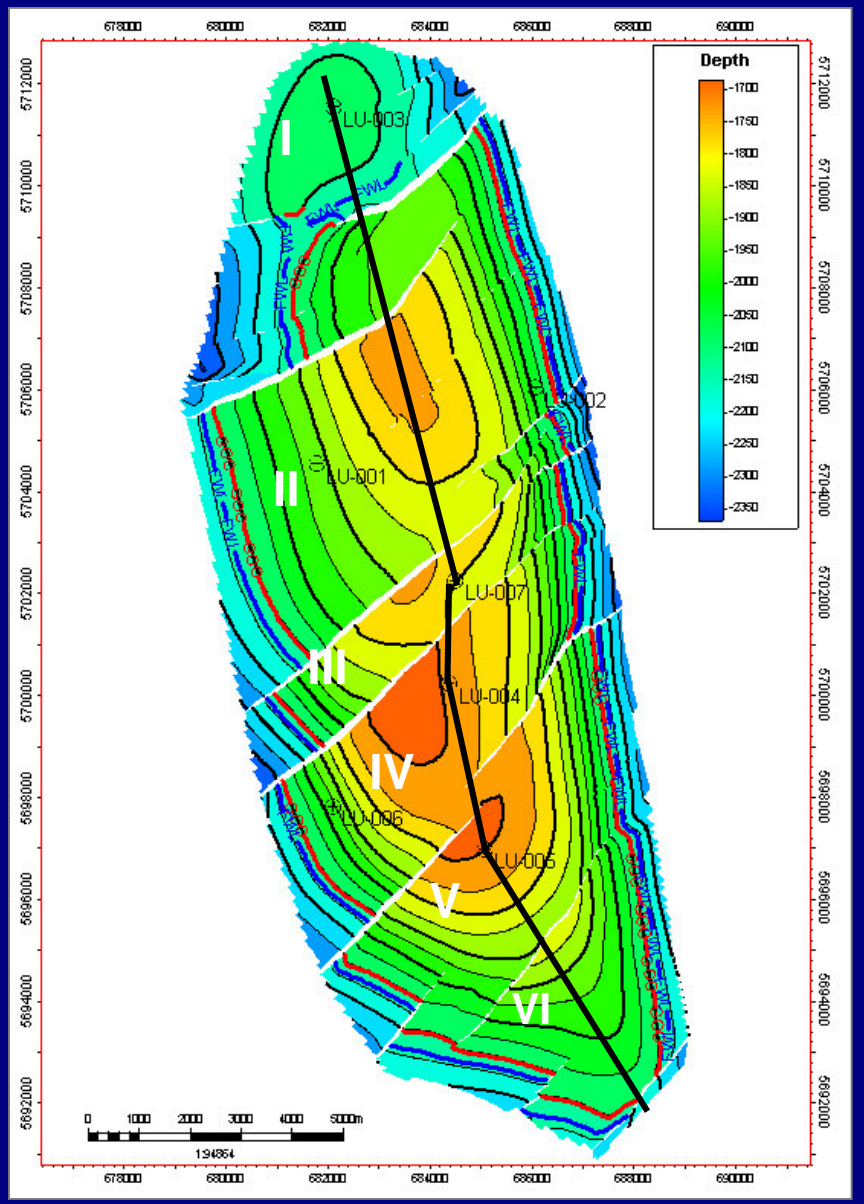
**Environment**

**1$^{st}$ LNG Plant in Russia**
**2 x 4.8 million tonnes p.a.**

**$100/second Spend**

# Lunskoye Gas Field

- **Discovered in 1984 and appraised with 7 wells**
- **Excellent gas reservoir with thin oil rim**
  - **GIIP 18.6 Tcf,**
  - **STOIIP 931 MMbbl**
- **One platform (Lun-A) can sustain 20 years production plateau for two LNG trains.**



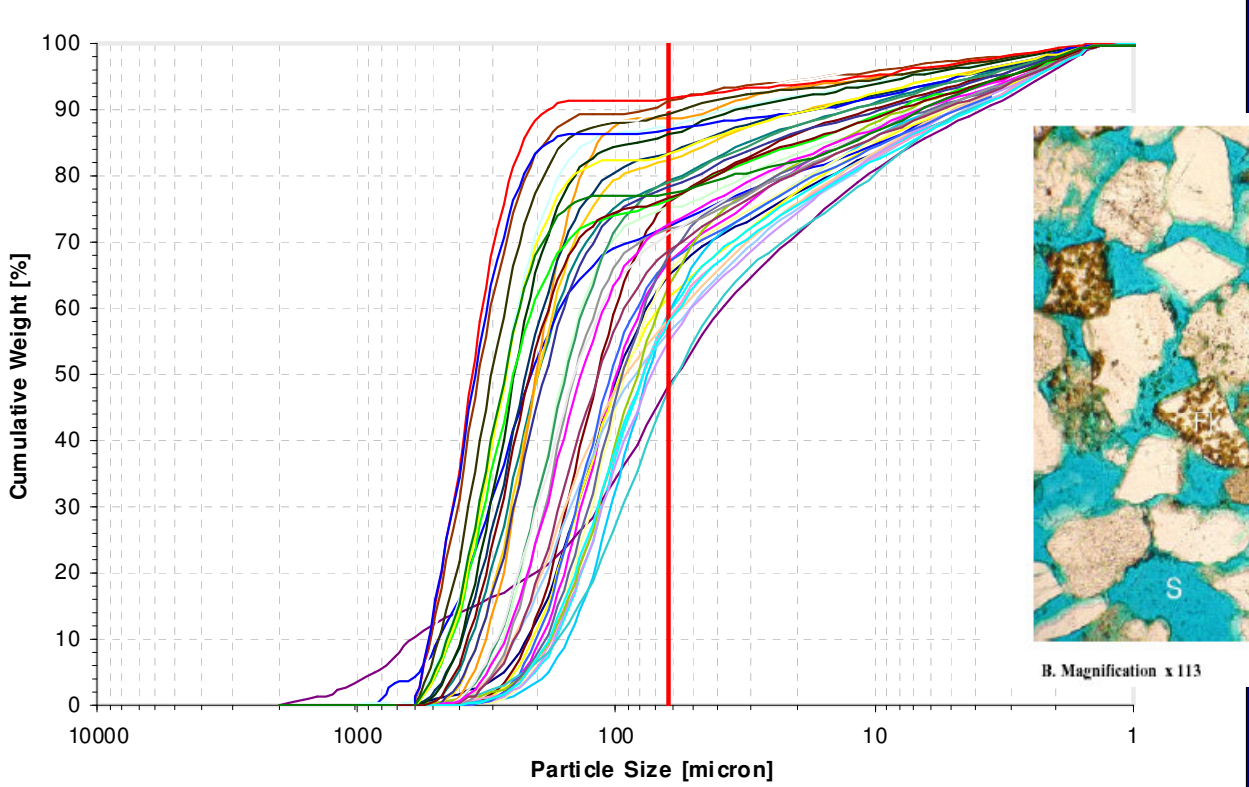
# Lunskoye Field – Formation Data

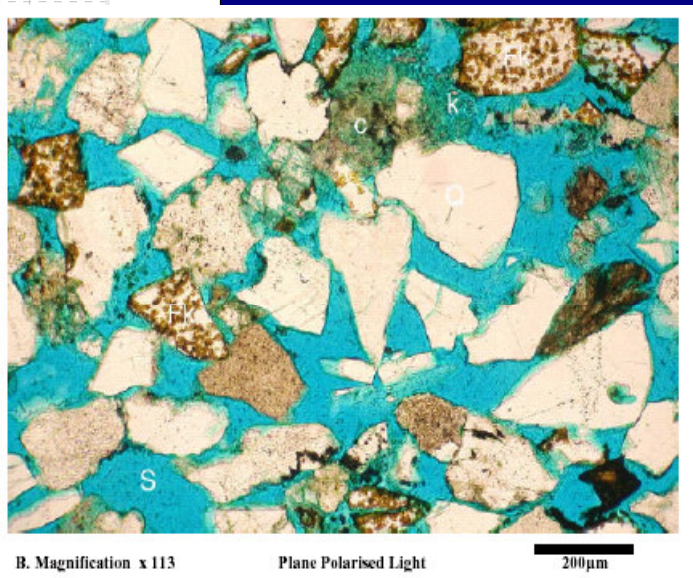
Aver Porosity = 25%,

$d_{50}$ = 55-357 (Av = 167µm)

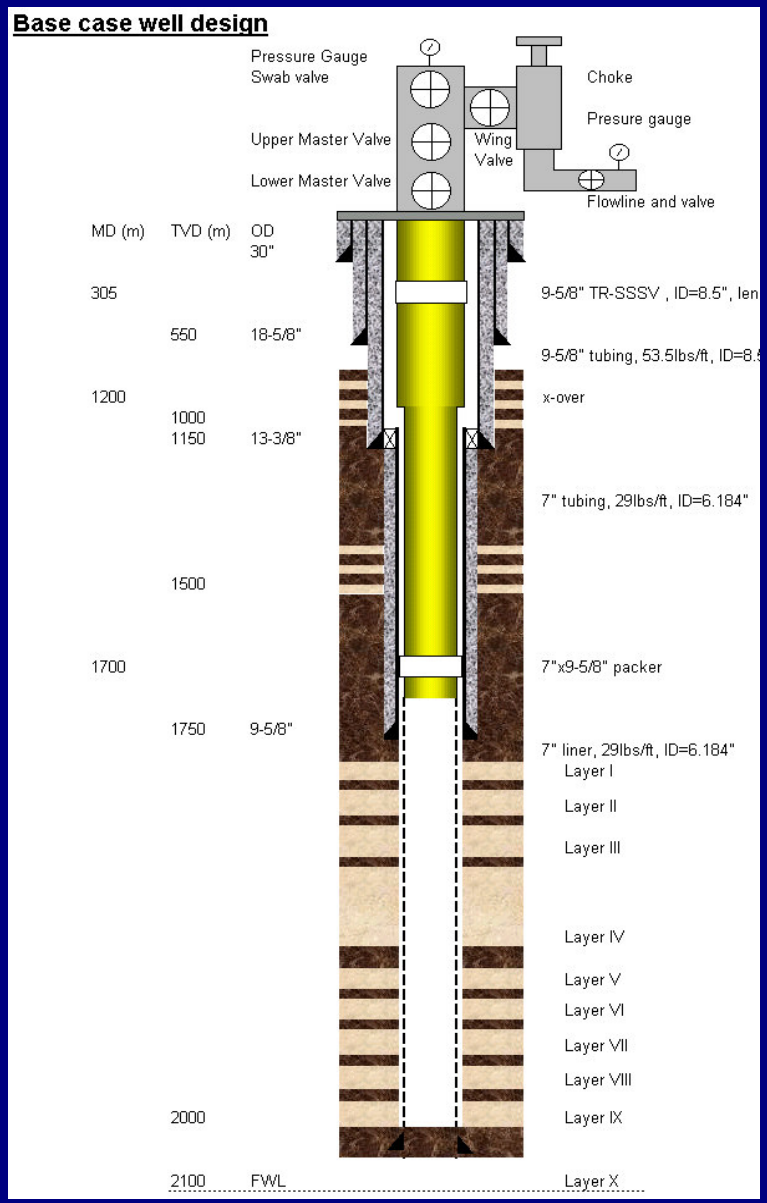
Perm = 150 – 1,200 mD,

Fines = 7-42 (23%)



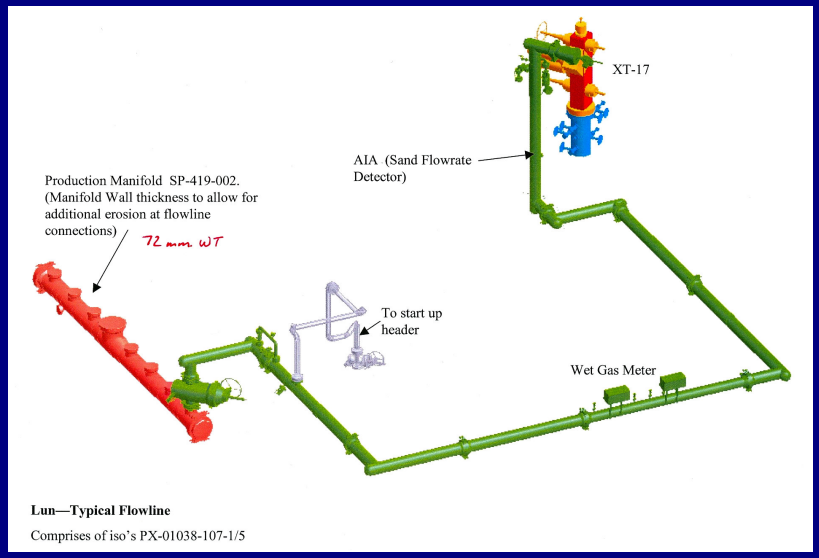



# Initial Gas Well Design, 2002



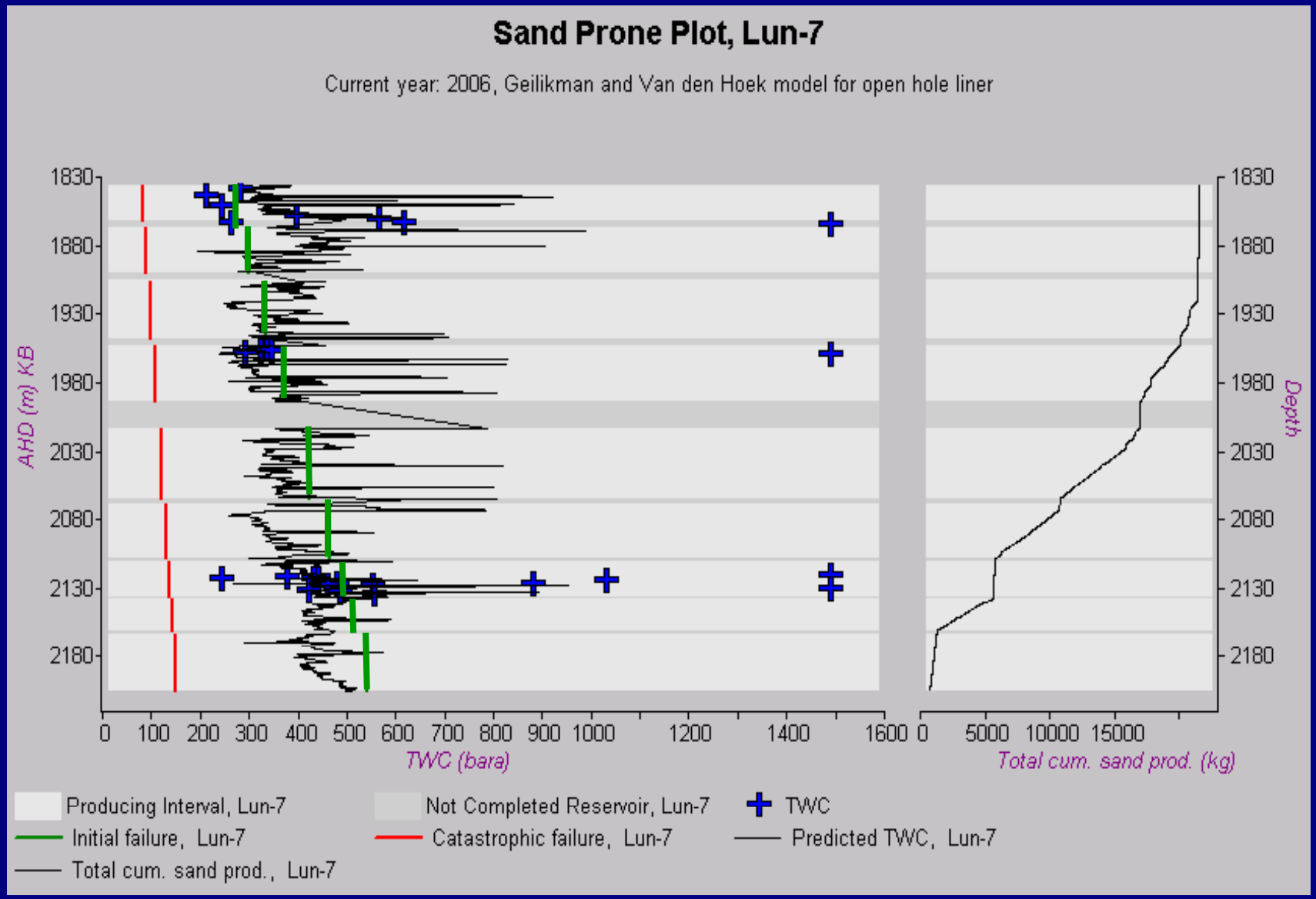

- 9-5/8” x 7” 13Cr tapered tubing, with Pre-Drilled Liner or Slotted Liner completion in open hole.
- Sand expected to be produced and managed, and retrofit sand control as required.
- Topsides designed for sand production (0.5 lbs/MMscf), with 1/2 tonne sand/day expected

# Follow-Up Work in 2002-2004

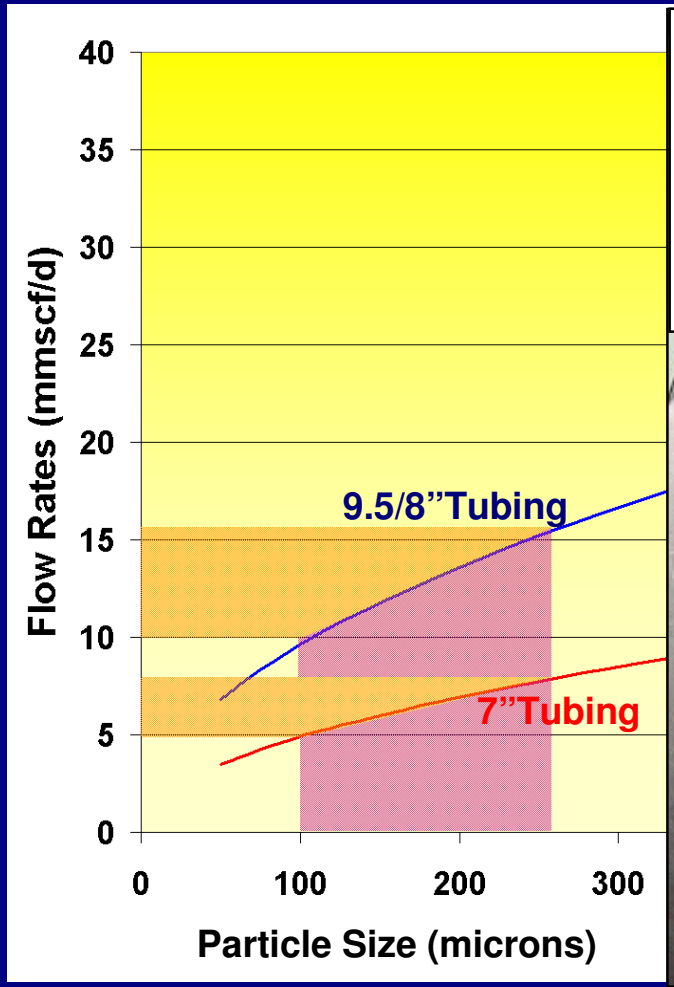



- Value Engineering of Topsides,
  - Sand handling equipment removed
  - Reduced 14" flowlines to 12" (erosion critical)
  - No test separator
- Acceleration of Gas Sales
  - No float in drilling schedule to enable retrofit sand control.
- In 2004: High rate gas wells & sand expected, with:
  - No sand exclusion downhole,
  - Minimal surface sand handling capability.

# 2004, Openhole Sand Estimate



# What happens if a well produces sand?




**Water Condensate Separator**

(Courtesy of A. Kooijman)

**If this happens on Lunskoye: A delay in the time to reach Plateau production would be 4-6 months minimum.**

# Back to the Drawing Board: Sand Face Completion Selection

Cased & Perforated

Open Hole Gravel Pack

Expandable Sandscreen

Standalone Screen

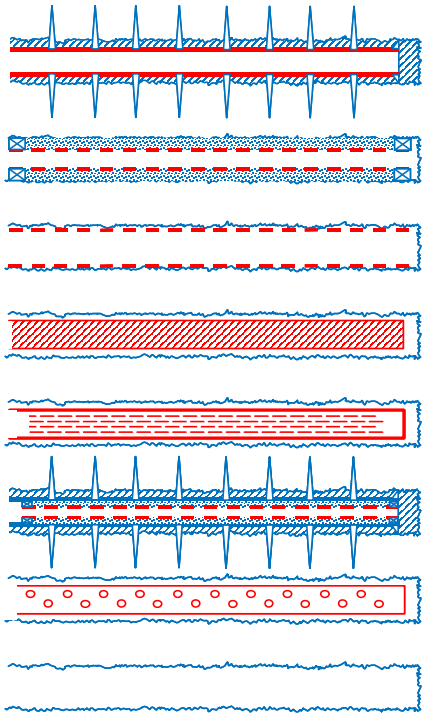
Slotted Liner

Internal Gravel pack

Predrilled Liner

Barefoot

SPE 88493



**But C&P has no screen/filter to stop sand …**

**…. so how much sand will be produced?**

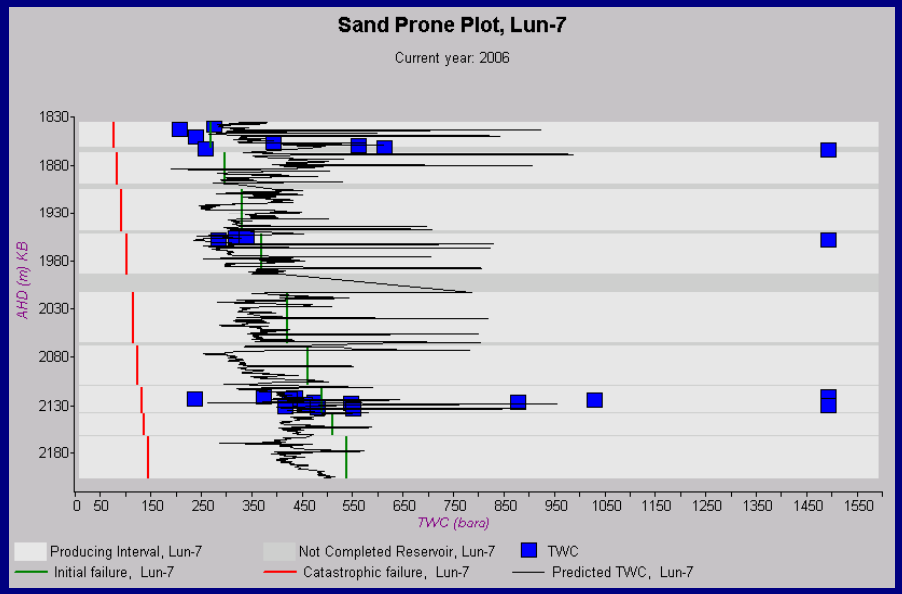
**…. how much gas production?**

| | Barefoot | Pre-drilled liner | Slotted Liner | Stand Alone Screen | Cased and Perforated | OH ESS | OH Gravel Pack |
|---|---|---|---|---|---|---|---|
| Overall Score | | | | | | | |
| Reliability | | | | | | | |
| Installation / Do-ability | | | | | | | |
| Capacity | | | | | | | |
| Cost | | | | | | | |
| HSE | | | | | | | |

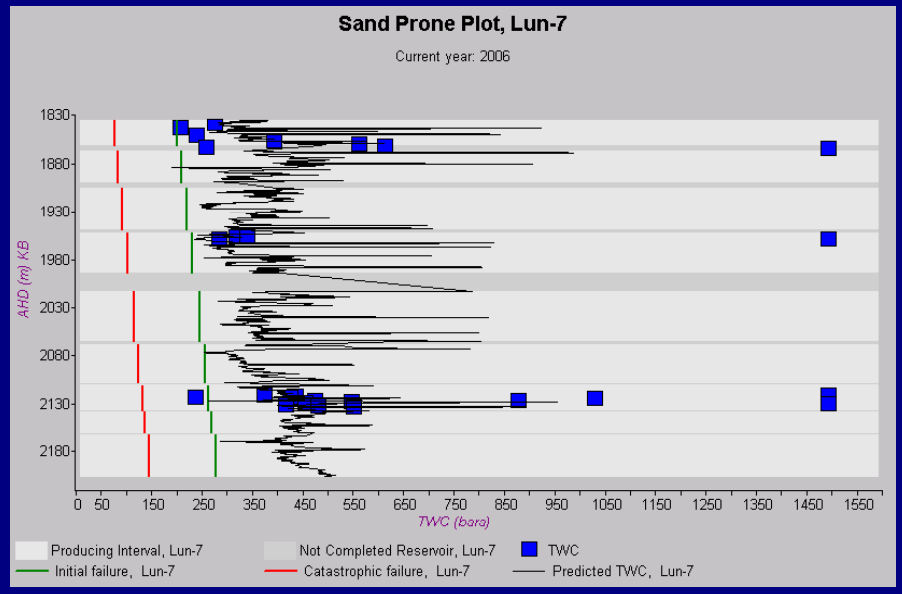
Good Option | Possible Option | Worst Option

# Openhole Vs Cased and Perforated: Sand Prediction

**Openhole**

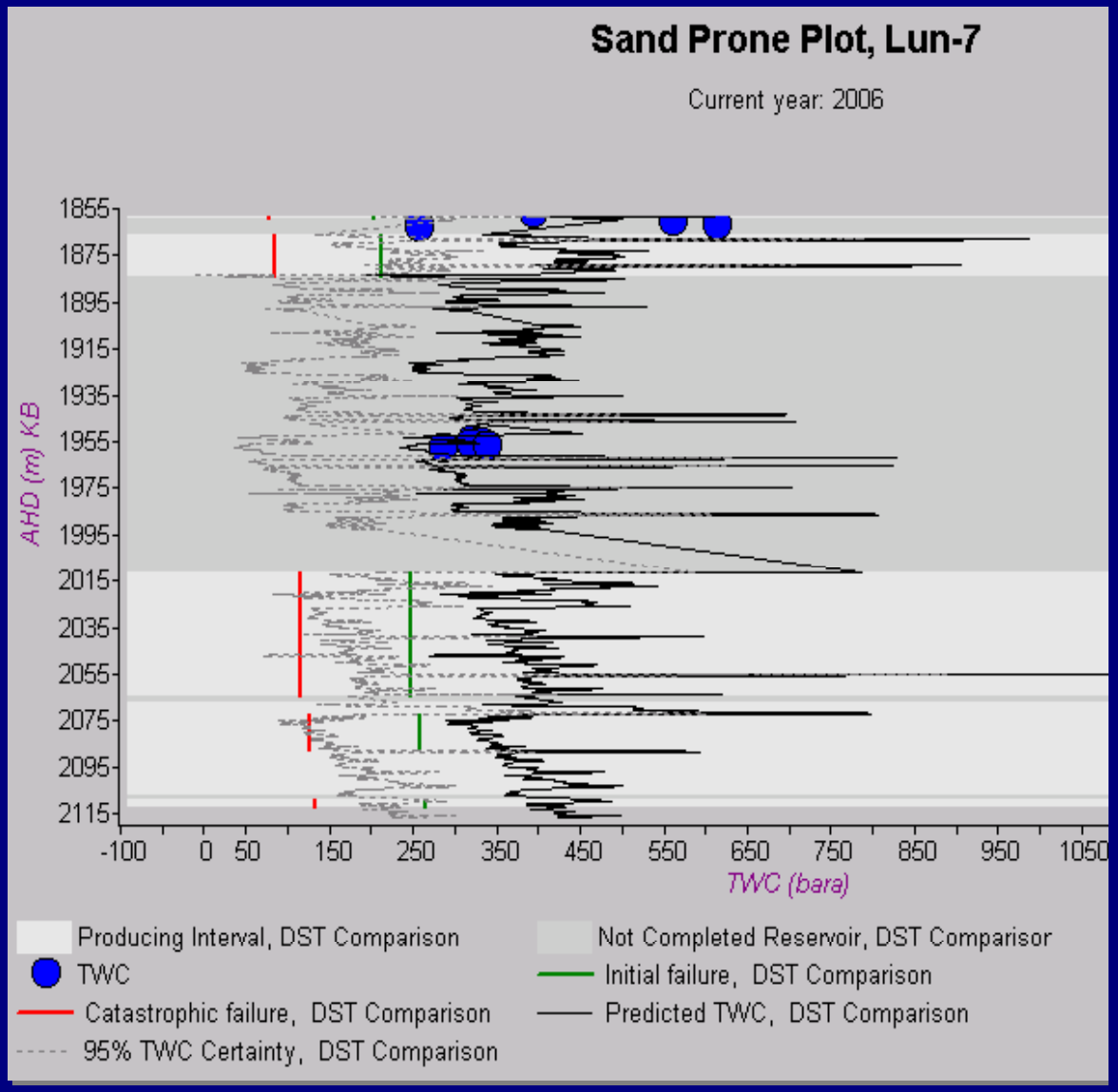



**Cased & Perforated**




Sand Production is expected to be delayed (with smaller volumes) with cased and perforated completions compared to openhole completions

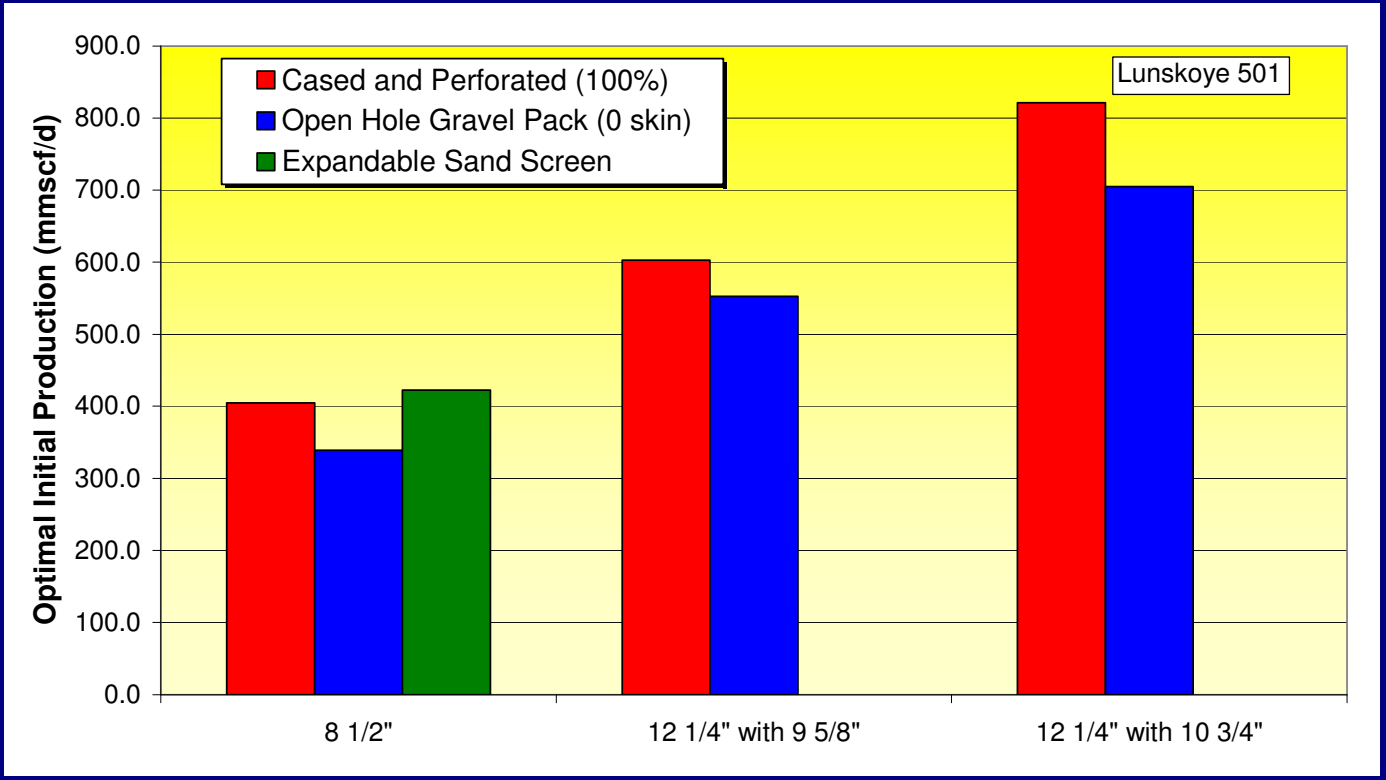
# 2004 Prediction Calibrations: Cased & Perforated




- **Drill Stem Tests from Lun-7 observed no sand**
- **Successfully predicted (Blind)**
- **Sand failure predictions also showed sand would not be expected in the DSTs performed on other wells – consistent with the observations.**

# Productivity Predictions: Lun-501

- Development well trajectories changed from vertical to inclined to increase reservoir exposure
- Completion sizes 8 ½” and 12 ¼” open hole considered



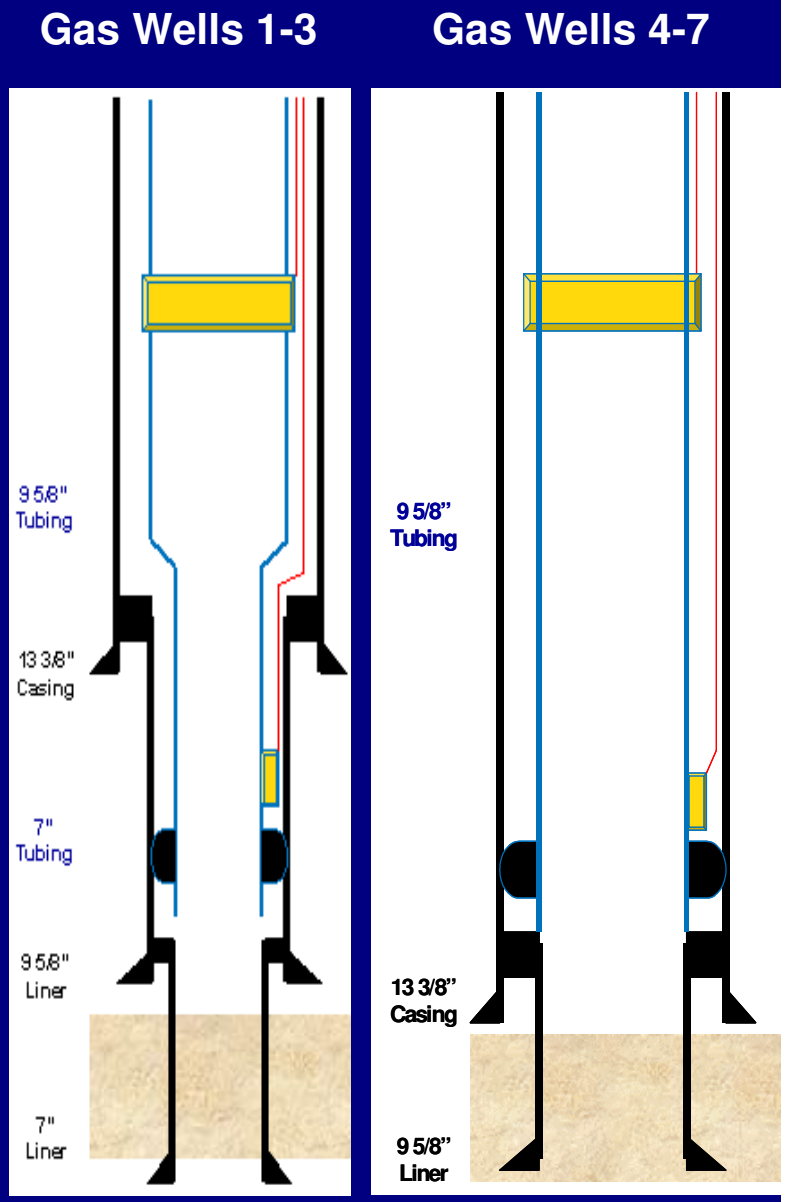
# Downhole: Sandface Completion Comparison

| Sand face completion | Pros | Cons |
|---|---|---|
| Cased & Perforated | Robust, Productive<br>Water Shut Off capability | Sand production later in field life |
| Openhole Gravel Pack | Downhole sand control | Very difficult to achieve in winter<br>Lower Productivity<br>Costly & Complex installation<br>No Water Shut Off capability |
| Expandable Sand Screen | Downhole sand control | Limited track record for high rate gas wells<br>No Water Shut Off capability<br>8 ½" hole only |

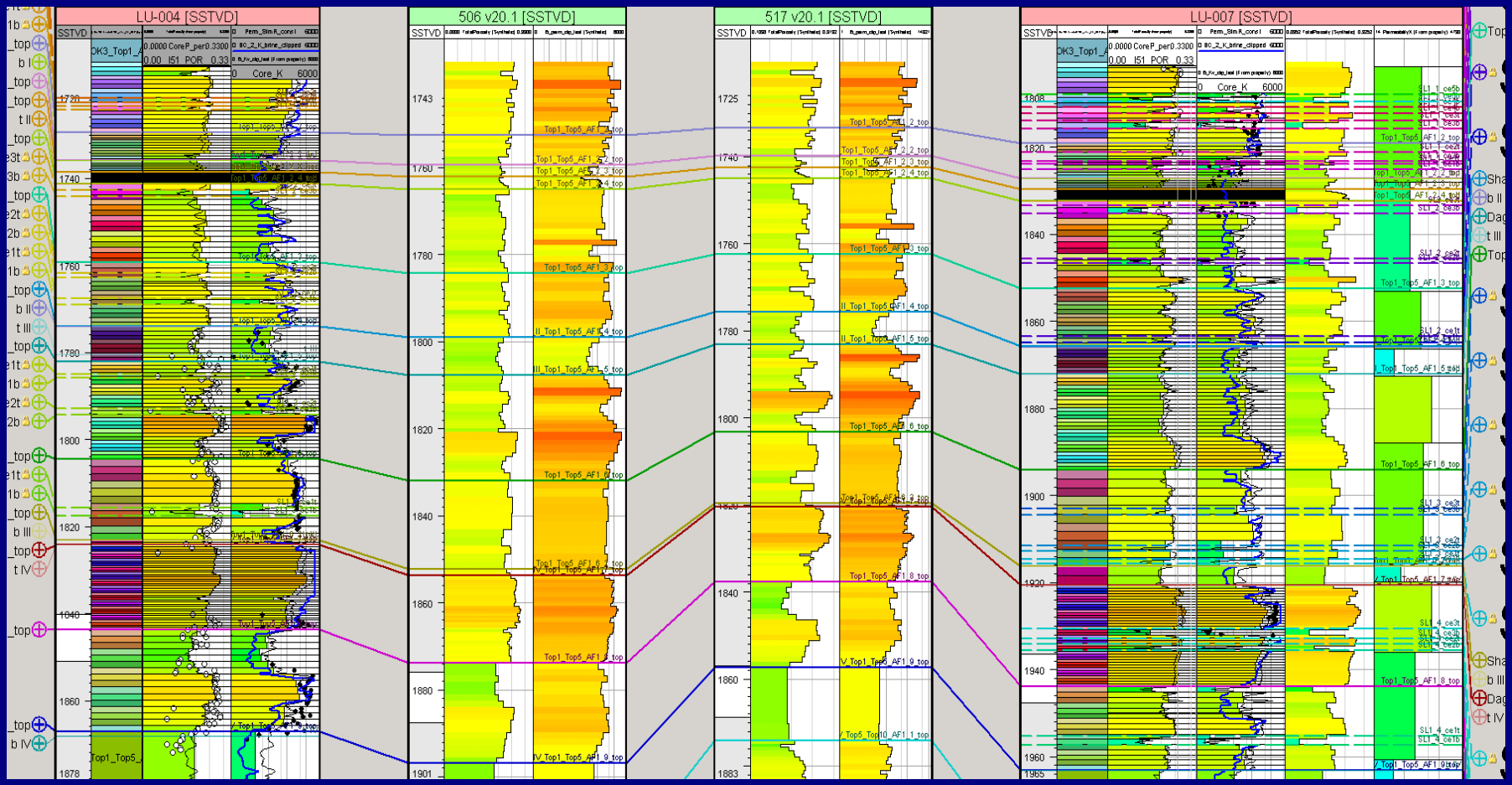
**Conclusion of sand study - use C&P and make detailed contingency design for ESS/OHGP.**

# Optimising Cased & Perforated Completion

- Development well geology estimated for 2m AHD intervals discretisation.
- 400 inflow intervals/well (~2 to 3m AHD).
- Sand Prediction gives failed intervals: these are not perforated.

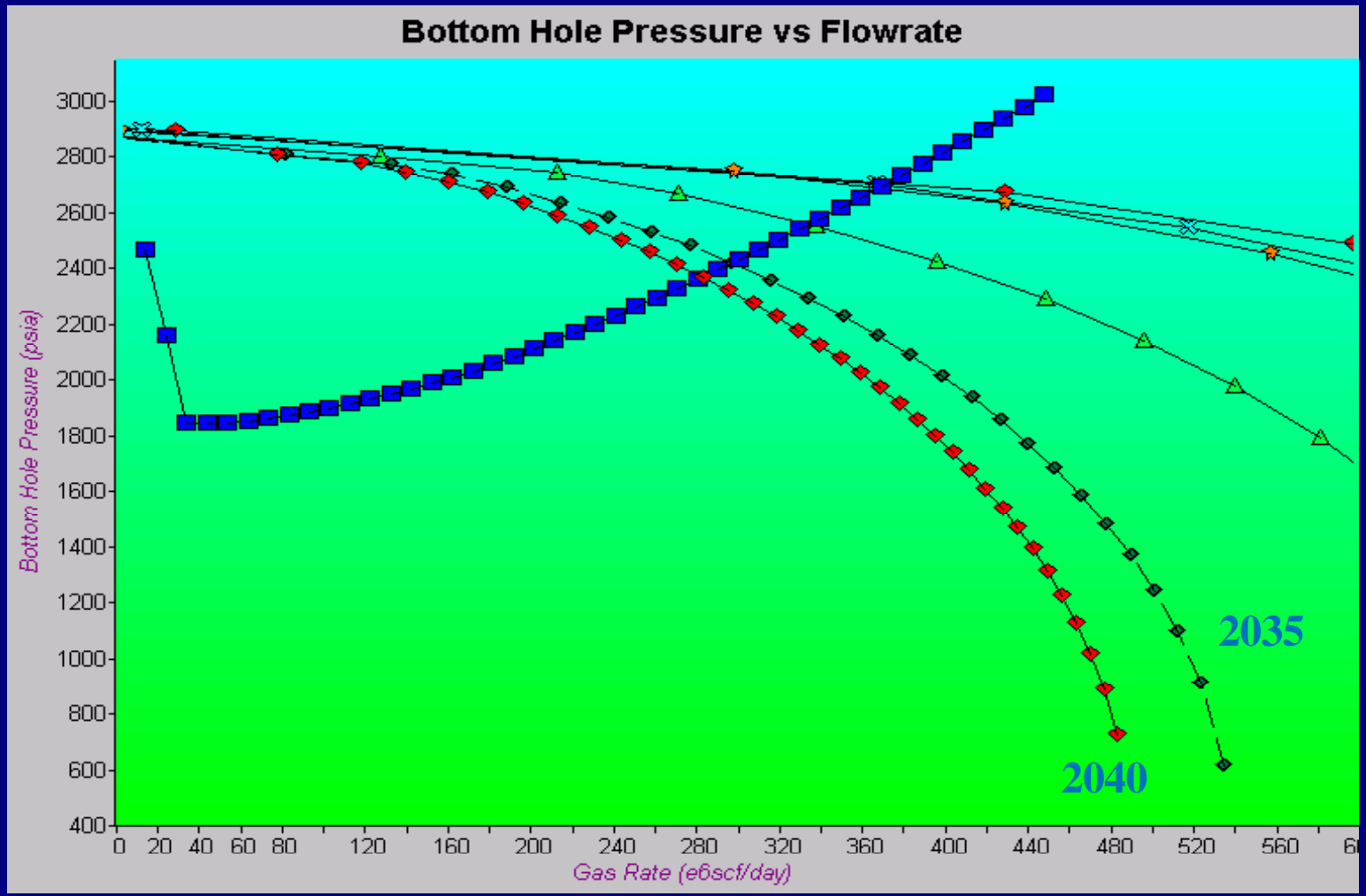


# Example of Petrel Discretisation of Daghinsky



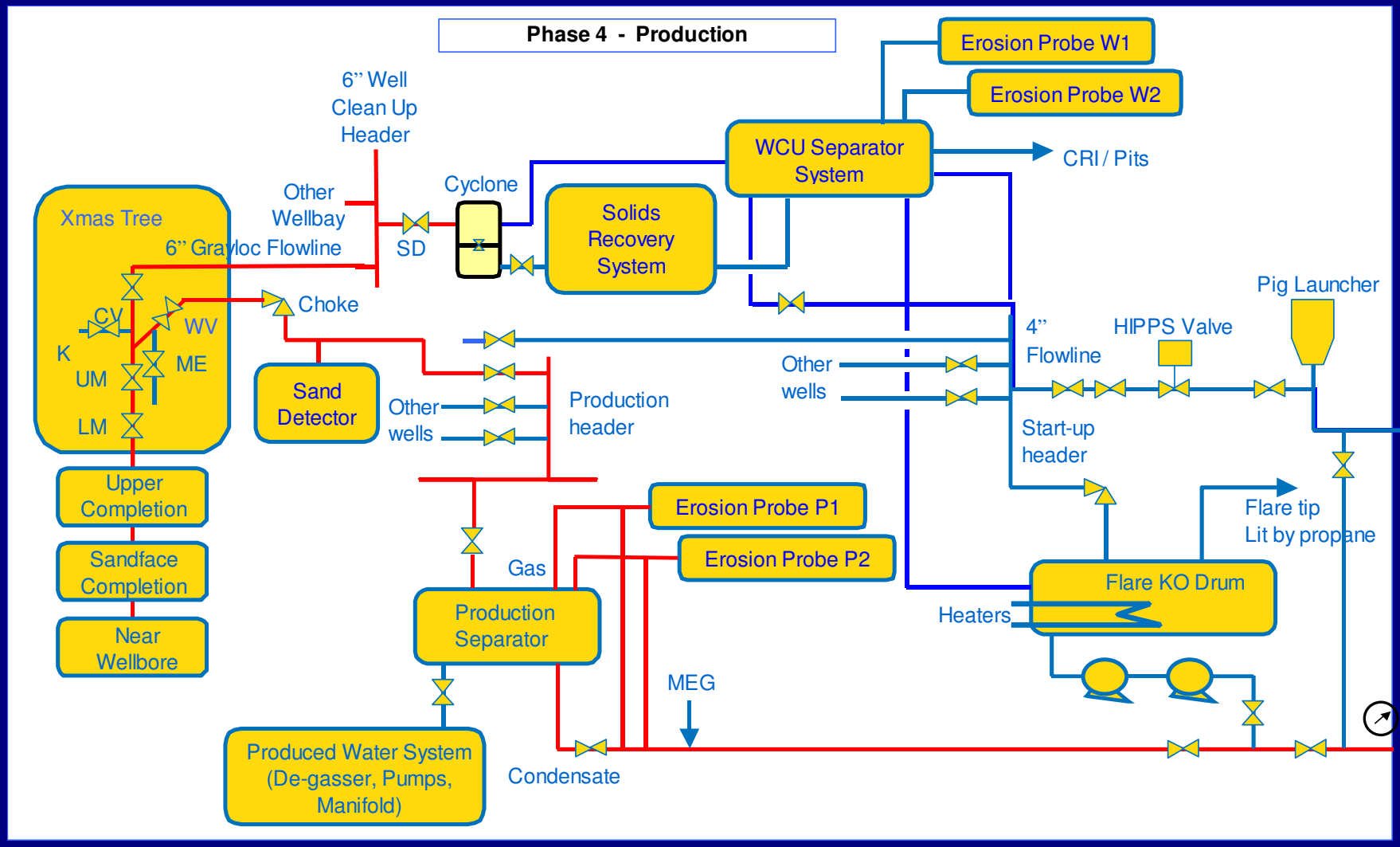

**2m Intervals**

# Impact on Initial Production with Selective Perforation




- Selective perforating based on sand free production until 2025

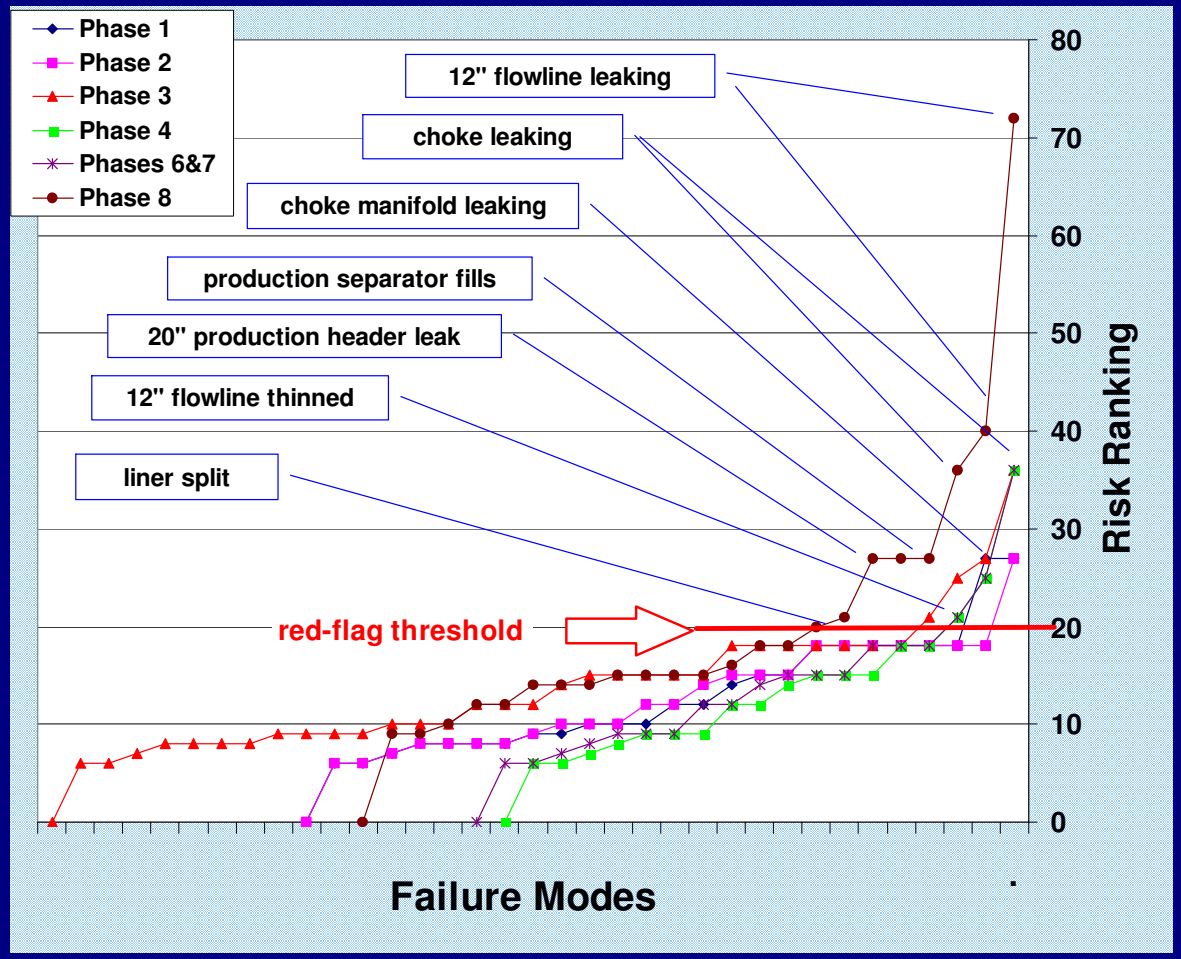
# QRA: Quantitative Risk Analysis



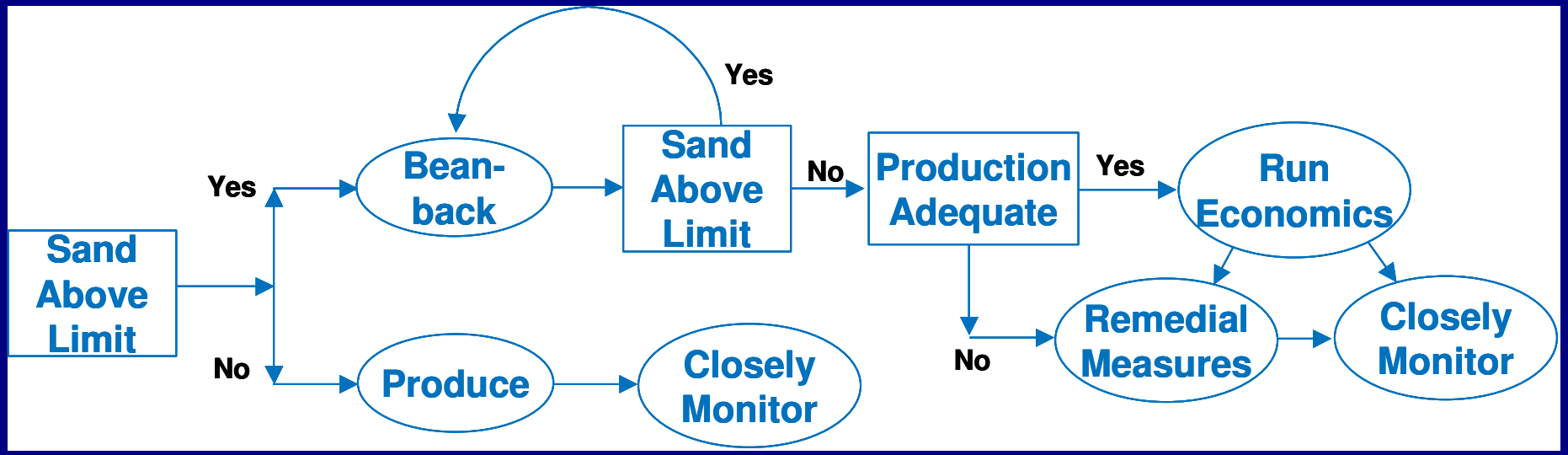
# Mitigation Measures to Reduce Impact of Sand Production

Example

- 12” Flowline
- Erode until detected
- Remedial Options
  - Maximise use Well Clean Up Unit
  - Small bean Up steps
  - Use clamp on sand detector
  - Non destructive testing



# Remedial Completion Options




## Remedial Measures Selection Matrix

| Selection criteria | Re-Perforate | Sand Consolidation/Polymer Shut-off | Cement squeeze & drill out | Cement Plug | Mechanical Plug | Inflatable Plug | Straddle Packers | Cased Hole ESS (WCS) | Wireline Conveyed Screen | Patch (Generic) (W/L & CT) |
|---|---|---|---|---|---|---|---|---|---|---|
| Through Tubing | | | | | | | | | | |
| Max Running OD<5.75" | | | | | | | | | | |
| ID restriction post deployment | | | | | | | | | | |
| Metallurgy CRA, 13Cr or higher | | | | | | | | | | |
| Deployment (W/L, CT, DP, W/O) | WL & CT | CT + SPT | CT | W/L & CT | W/L blanks 4-5m | W/L blanks 4-5m | W/L & CT & Blank | DP | W/L | |
| Length Range | | 3m/treatment | | | | | 100m??? | | | |
| Live Deployment? (Y/N) | | | | | | | | | | |
| Collapse Rating (psi) | | | | | | | | | | |
| Mid interval sand production | | | | | | | | | | |
| Bottom sand production | | | | | | | | | | |
| Sand location unknown | | | | | | | | | | |
| Whole section sanding | | | | | | | | | | |

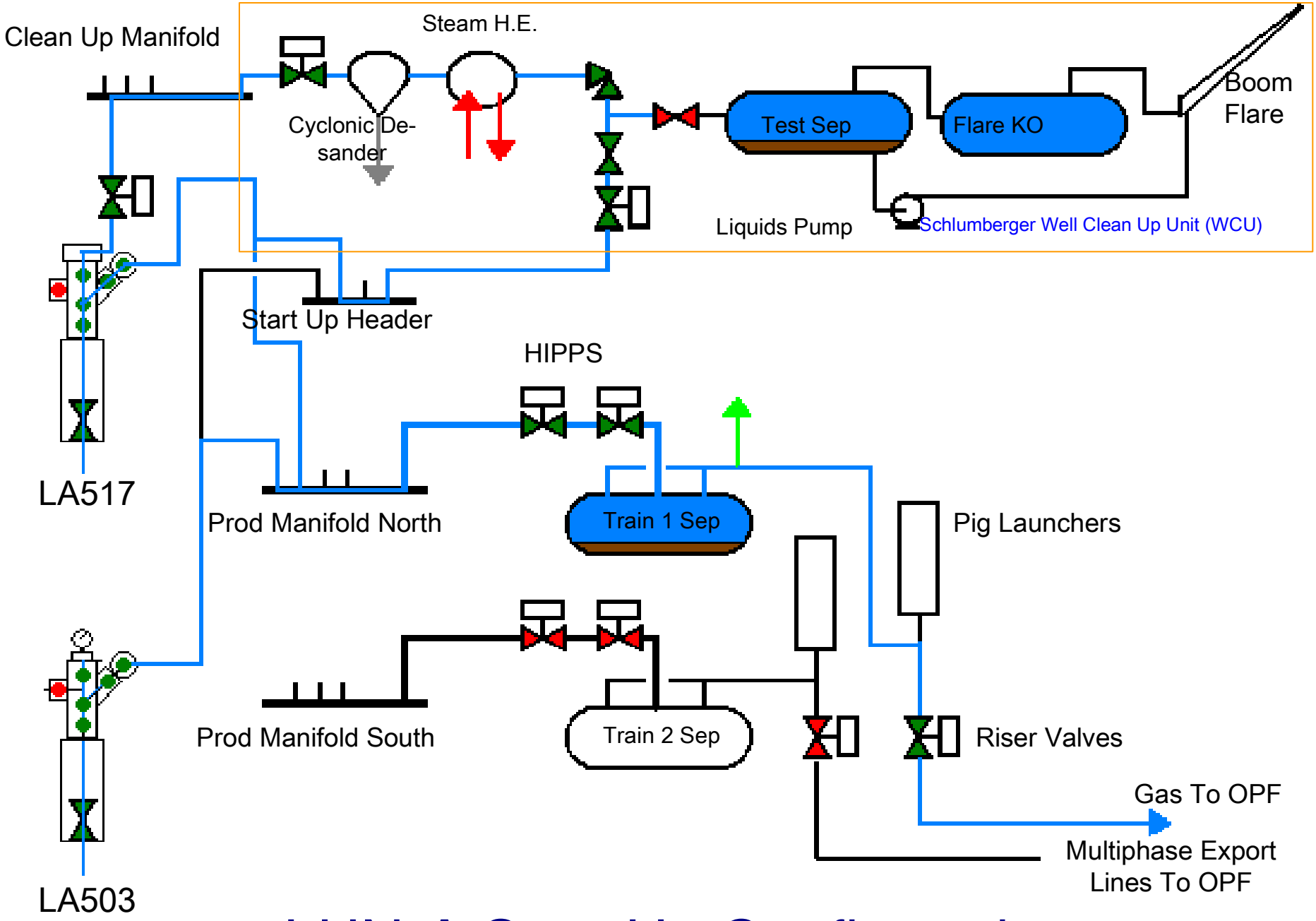
# Sand Management Plan

- **Lunskoye Sand Management Plan:**
  - **Completion Design**
  - **Quantitative Risk Assessment**
  - **Monitoring**
  - **Roles & Responsibilities**
  - **Contingency Planning**

- **Apply other operator's experience**

# The $22 Billion Question?

Did it work?




# LUN-A Start Up Configuration


Lunskoye Clean Up, Dec 2008

# Bean Up Summary

- No incidents or accidents
- Each well delivers:
  - 350 MMscf/d or 10 Mln.$m^3$/d gas
  - Practically no sand seen (half a cup)
- Lunskoye gas wells are:
  - Russia's largest gas wells
  - Largest offshore gas wells in the world

# Conclusions

- Pre-Drilled Liner produced too much sand
- New Sand Failure Prediction Tool predicts onset of sand & quantifies volumes
- Preferred new completion design is Cased and Selectively Perforated
  - Defer sand production to 2025+
  - Sand levels lower and more manageable
- Quantitative Risk Assessment to address risk
- Lunskoye Sand Management Plan to manage risk

# Final Words

- Cased & Selectively Perforated Wells deliver World Class Performance
  - Maximise gas production
  - Minimise sand production

## Acknowledgements

To those that did the work…

- David Brown, Jeroen Webers, Christoph Zerbst (Sakhalin Energy), Philippe Brassart, Hamed Subhi & Tony Addis (Shell)

And to those that paid for it….the Shareholders

- Gazprom
- Shell
- Mitsui
- Mitsubishi

# Questions?

# References


- SPE 116713: Sand Quantification: The Impact on Sandface Completion Selection and Design, Facilities Design and Risk Evaluation
- SPE 112099: Applying Sand Management Process on the Lunskoye High Gas-Rate Platform Using Quantitative Risk Assessment
- SPE 114805: The Integrated Use of New Technology in the Development of the Sakhalin II Project