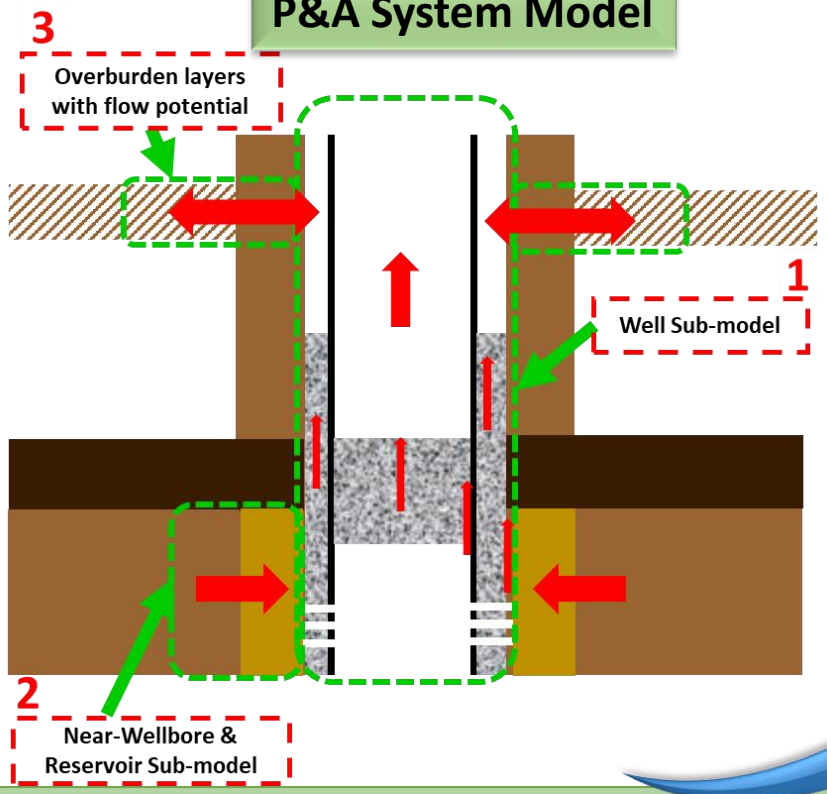
Application of Flow Modelling to a Risk-based Approach to Well Decommissioning

Caroline Johnson, Morteza Haghighat Sefat, David Davies
Institute of Petroleum Engineering

Risk-based approach to Well P&A Design

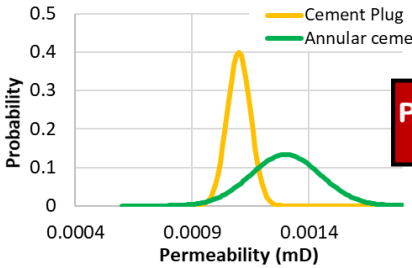
- UK well P&A expenditure forecast over the next decade: £ 7.5 billion*
- Urgent business need for a **risk-based** approach → fit for purpose, well specific design.
- **P&A system** long-term performance modelling required to assess risk and support cost-saving decision making process

P&A System Model



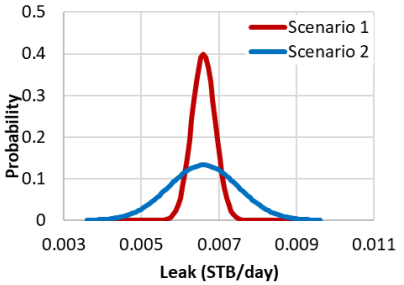
Probabilistic Analysis

Inputs:
Expected properties of cement plug/sheath



P&A System Model

Output:
Probability of flow to surface



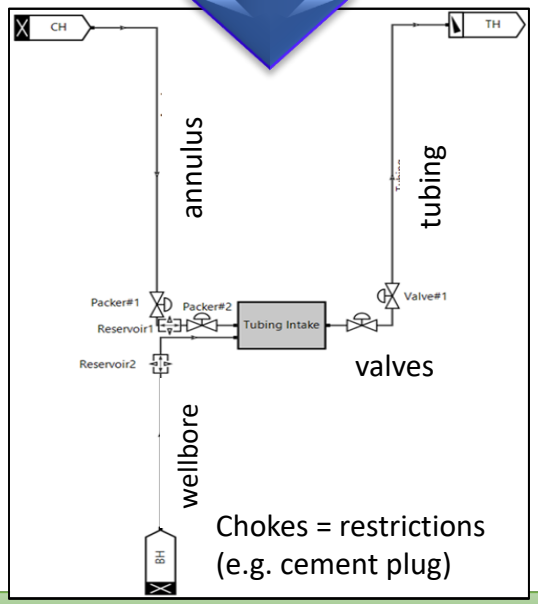
✓ Probabilistic evaluation of proposed P&A scenarios

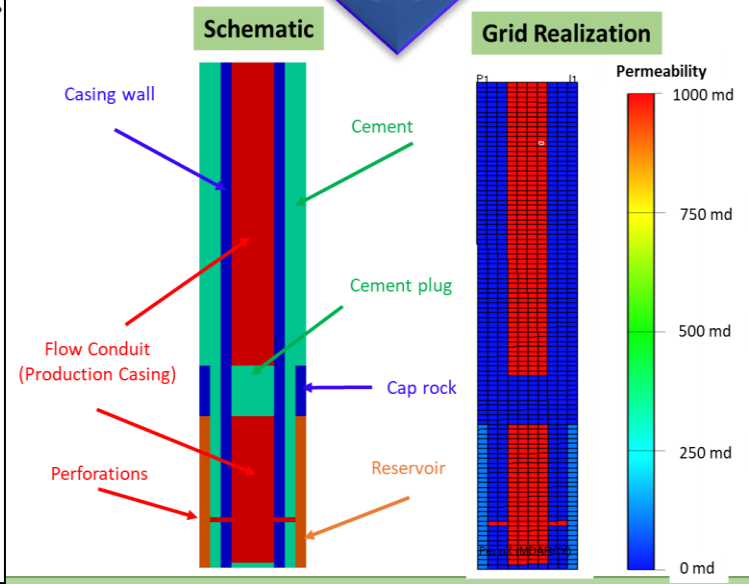
*2018 Decommissioning Insight, Oil & Gas UK

Possible Modelling Techniques

	Upscaled Steady State	Transient Wellbore Modelling	Numerical Grid-Based Simulation
Key Adv.	• Simple to implement	• Captures (early) transient effects	• Accurate flow through cement (i.e. porous medium) • Performance over time (~1000s of years)
Key Disadv.	• No time dependence	• **Approximation:** cement modelled as chokes • Unsuitable flow correlations • Computationally expensive	• **Approximation:** annular spaces modelled as very high perm & porosity medium.

$$Q = \left(\frac{kA}{\mu L}\right)(\Delta P - \rho g L \cos\theta)$$

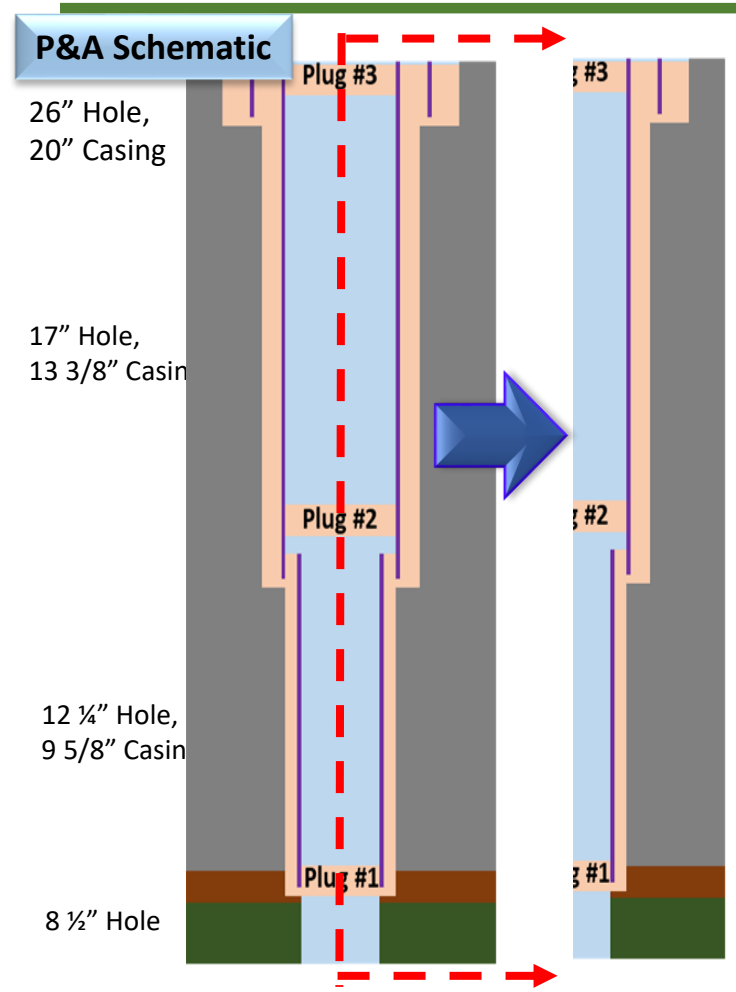


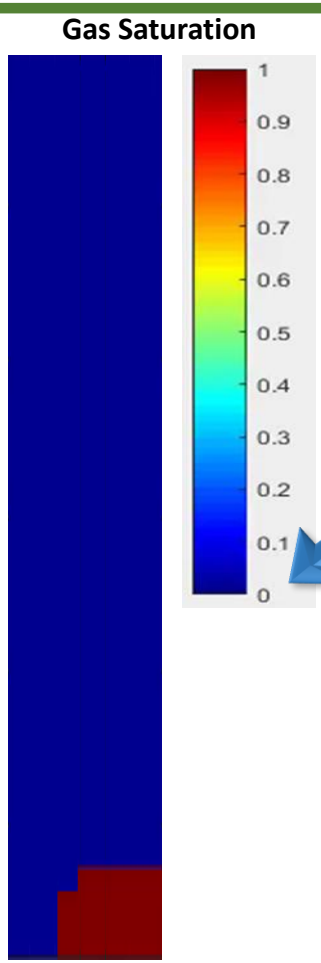


*Moeinikia, F., Ford, E. P., Lohne, H. P., Arild, O., Mansouri Majoumerd, M. & Fjelde, K. K. 2018. Leakage Calculator for Plugged-and-Abandoned Wells. *SPE Production & Operations*.

Developed Grid-Based Framework – Sample Application

P&A Schematic





Using:

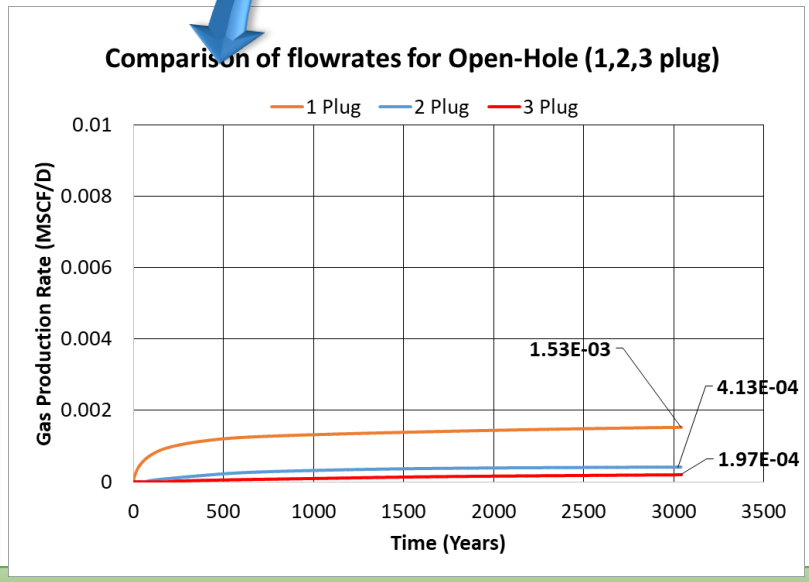
- In-house pre/post processor
- Commercial simulator as back-end engine.

Scenario:

- **Open hole completion**
- **Reservoir:** Gas, Constant P = 5000 psia
- **Wellbore:** Water-saturated, intact cement k= 1µD

P&A Model Outputs

- Animation
- Flowrates



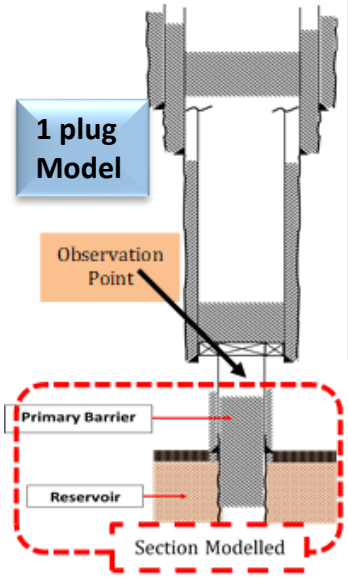
- **Results consistent with expected trends**
- **Validation of absolute flowrates using physical experiments would be ideal**

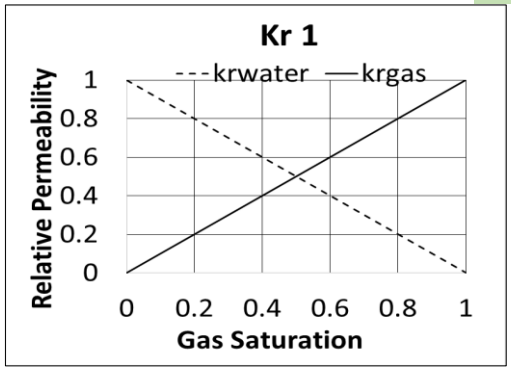
Key parameter: effective permeability (k_{eff})

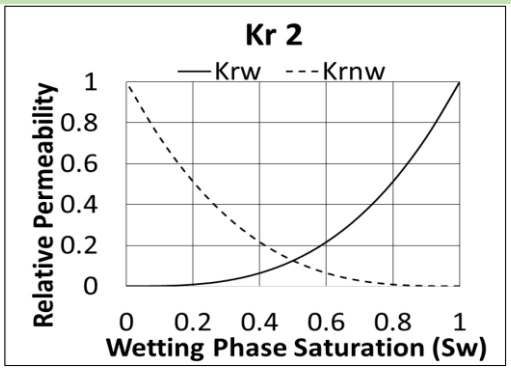
Multiphase flow in porous medium

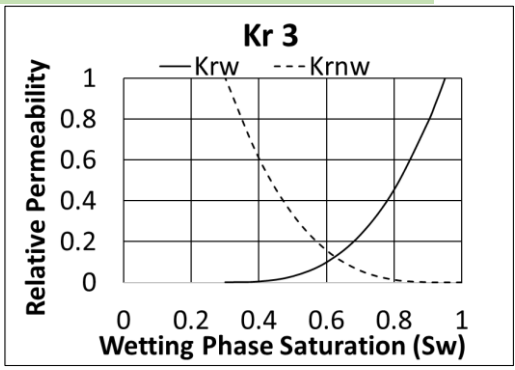
Effective Permeability

$k_{eff} = k.k_r$ (k = absolute permeability, k_r = relative permeability)

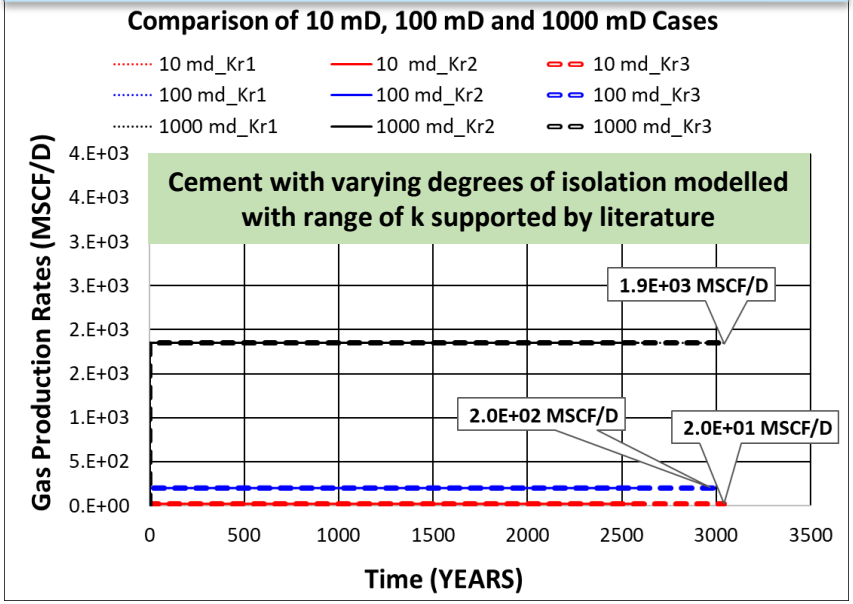








Sensitivity Study: Simulated Flow Rates

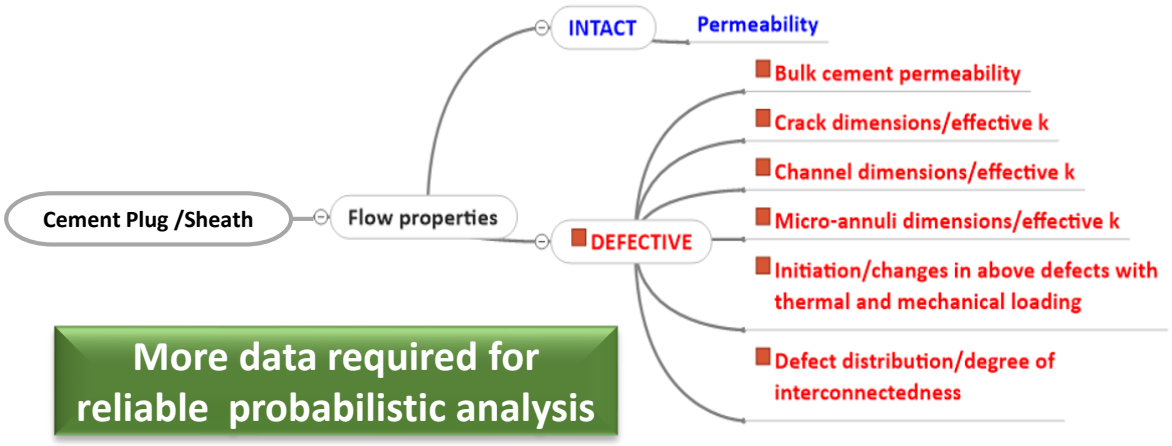


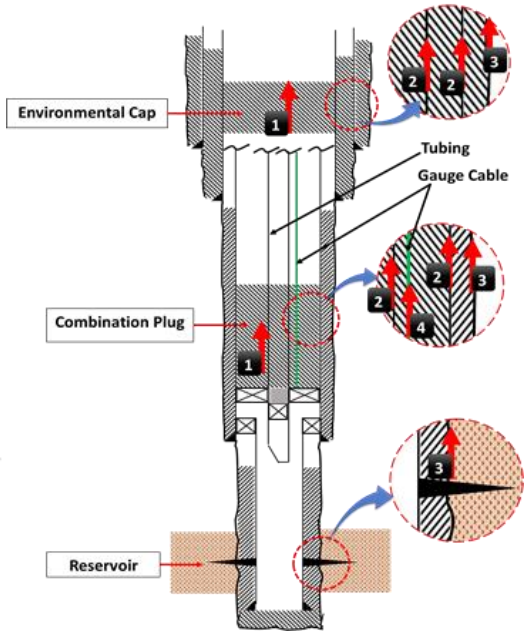
Absolute k (with its associated uncertainties) is a more important parameter than k_r.

✓ **Model application: identify most important input parameters**

Conclusions

- Numerical grid-based finite difference modelling works!
- The key input: k_{eff} of cement, driven primarily by the absolute k.
- To improve reliability (especially for **probabilistic analysis**)
  - more data and a deeper understanding of flow properties of cement with different degrees of isolation required.
- All P&A scenarios can be modelled using our developed framework,
  - including through-tubing P&A, which is of particular interest from a cost-saving perspective.





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Software license provided by Schlumberger

Email: Dr. Morteza Haghighat Sefat (m.h.sefat@hw.ac.uk)