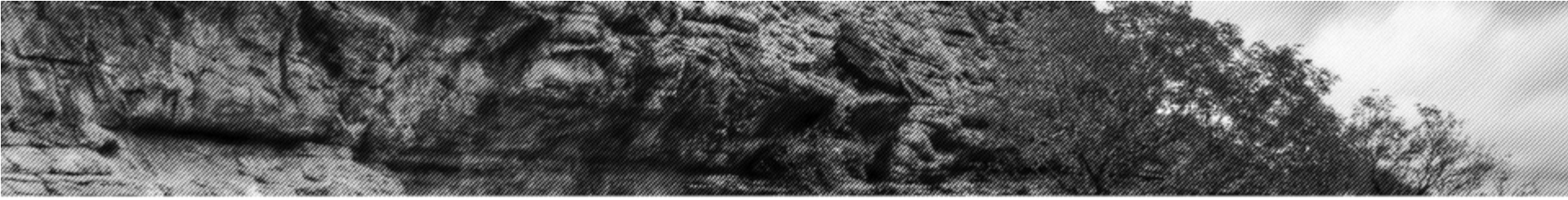

Reviewing Water Resource Impacts of Unconventional Gas Development

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Australian Government
National Water Commission
Australian Research Council

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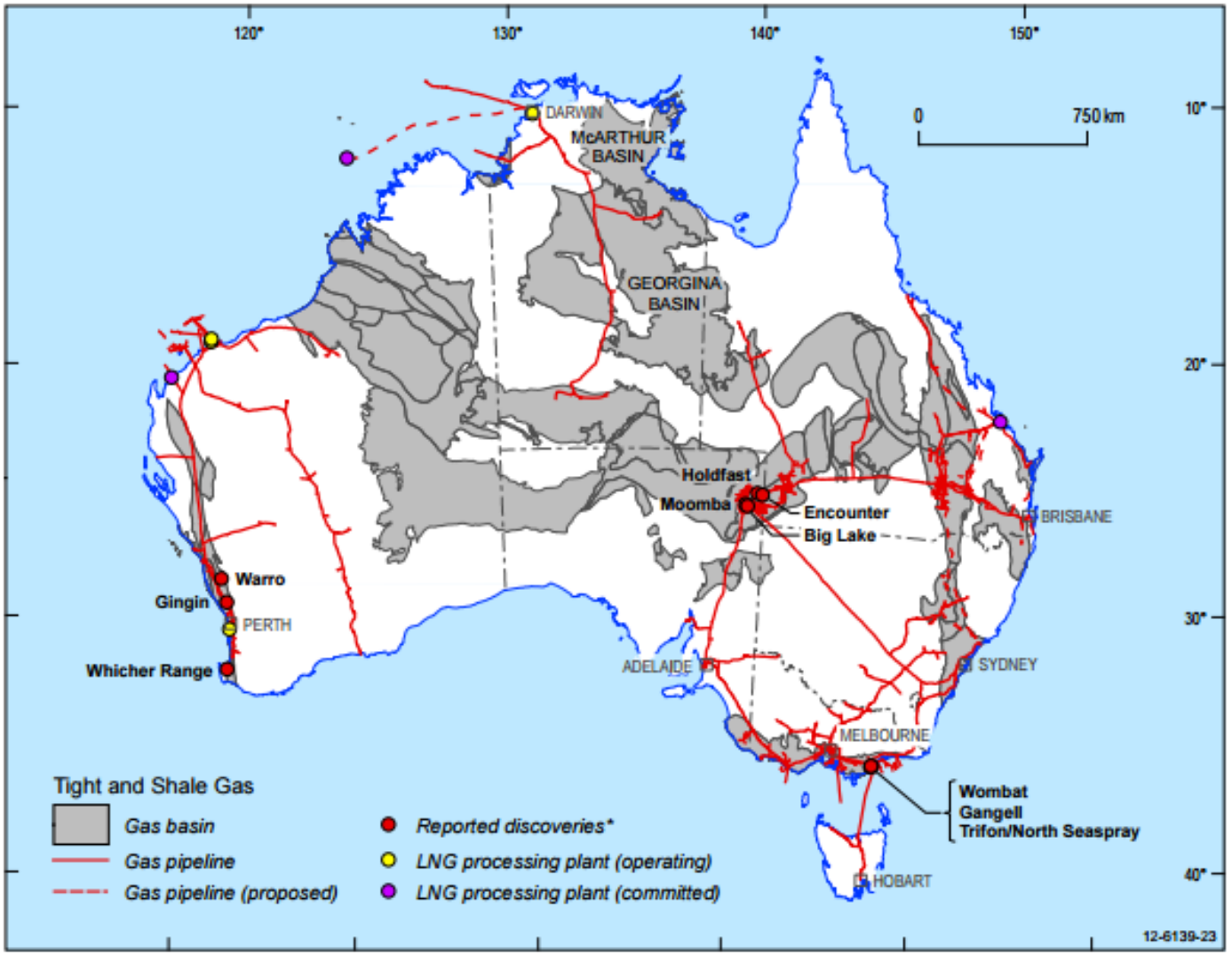
SOUTH AUSTRALIAN GROUNDWATER FORUM – July 2015

Prevalence of Unconventional Gas Resources in Australia



Basins with tight gas and shale gas resource potential and gas infrastructure:
Source: Geoscience Australia and BREE, 2012, *Australian Gas Resource Assessment 2012*

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Valid concerns vs. public hysteria

Table 4.2: Key risks for hydraulic fracturing and worst case frequency

# 1	Spill (20,600 litres) of a transport load of water without chemicals **[1 in 50,000]**.
# 2	Spill (1,890 litres) of concentrated liquid biocide or inhibitor **[1 in 4.5 million]**.
# 3	Spill (227 kg) of dry additive **[1 in 4.5 million]**.
# 4	Spill (1,135 litres) of diesel from ruptured saddle tank on truck (road wreck) **[1 in 5100]**.
# 5	Spill (13,250 litres) of fuel from standard field location refueler (road wreck) **[1 in 1 million]**.
# 6	Spill (80,000 litres) of well-site water (salt/fresh) storage tank – no additives **[1 in 1000]**.
# 7	Spill (190 litres) of water treated for bacteria control **[1 in 10,000]**.
# 8	Spill (190 litres) of diesel while refuelling pumpers **[1 in 10,000]**.
# 9	Spill (80,000 litres) of stored frack water backflow containing chemicals **[1 in 1000]**.
# 10	Frack ruptures surface casing at exact depth of fresh water sand **[1 in 100,000]**.
# 11	Frack water cooling pulls tubing out of packer, frac fluid in sealed annulus **[1 in 1000]**.
# 12	Frack opens mud channel in cement on well less than 2000 feet deep **[1 in 1000]**.
# 13	Frack opens mud channel in cement on well greater than 2000 feet deep **[1 in 1000]**.
# 14	Frack intersects another frac or wellbore in a producing well **[1 in 10,000]**.
# 15	Frack intersects an abandoned wellbore **[1 in 500,000]**.
# 16	Frack to surface through the rock strata (well less than 2000 feet deep) **[1 in 200,000]**.
# 17	Frack to surface through the rock strata (well greater than 2000 feet deep) **[no cases]**.
# 18	'Felt' earthquake resulting from hydraulic fracturing **[no cases in US]**.
# 19	Frack changes output of a natural seep at surface **[1 in 1 million]**.
# 20	Emissions of methane, CO_2, NO_x SO_x… **[high frequency]**.

Adapted and tabulated from information in King, 2012.

Review of unconventional gas literature

- Funded by Department of State Development
- *Global* review of literature
  - Emphasis on what's relevant to Australia

- Five topics:
  - Groundwater contamination
  - Surface water contamination
  - Subsidence
  - Aquifer drawdown
  - Seismicity

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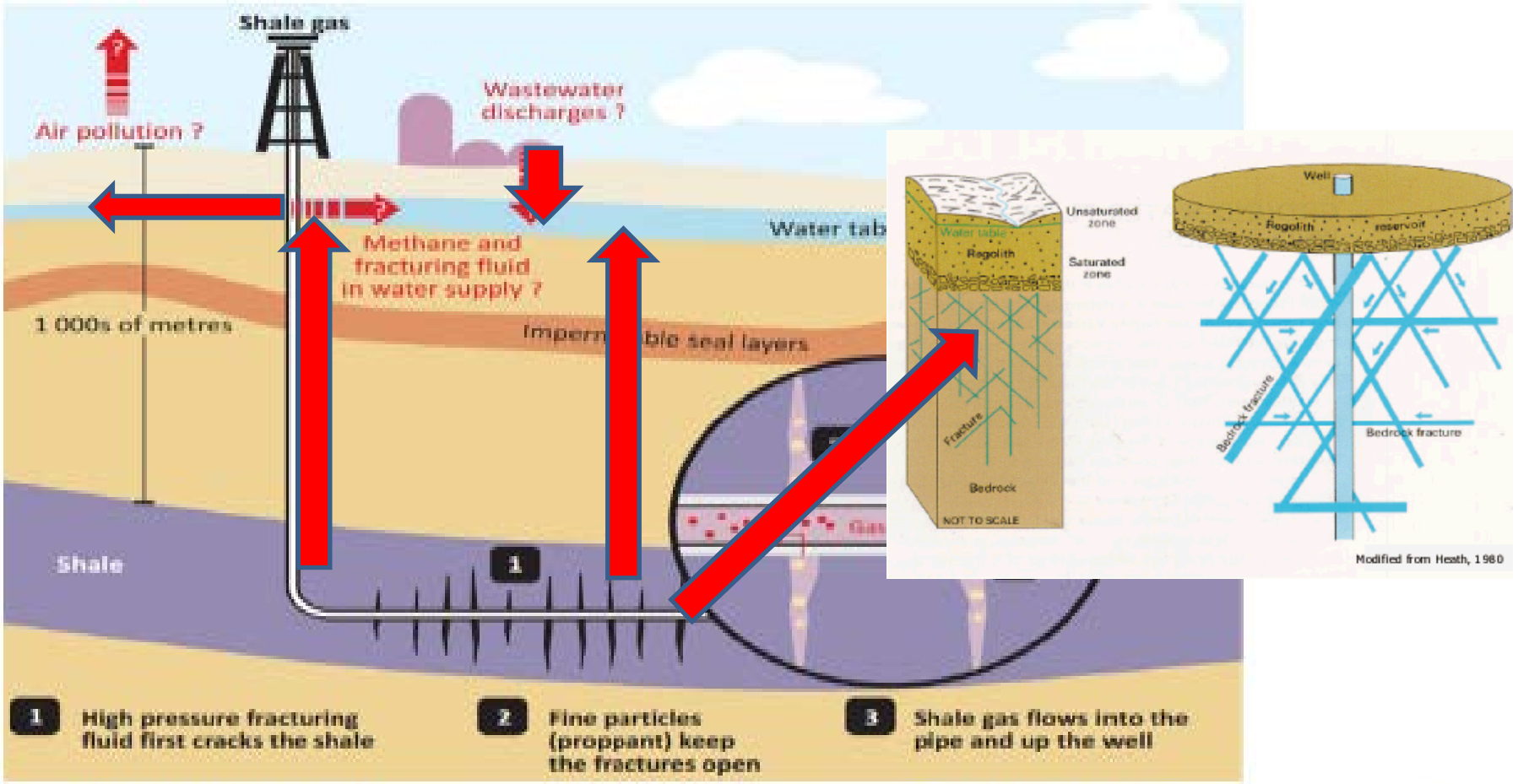
For each topic:

- Pathways
- Observational evidence
  - ie surface spills recorded, methane detection
- Theoretical models
  - typically box models with assumptions made
- Analytical solutions
  - lacking in the literature

Contamination pathways, ie for groundwater:



Source: Wang et al. (*Renewable and Sustainable Energy Reviews*,

Observational:

- “The Pennsylvania Department of Environmental Protection found 52 separate cases of methane migration in a five-year period ending in 2009. There are approximately 71,000 active gas wells in Pennsylvania. This corresponds to a 1.5×10^{-5} (1 in 7,000) chance of a well leaking each year. Assuming a short 10-year well lifespan, the lifetime well leak risk is **1 in 700**.”

Source: Rozell and Reaven (Risk Analysis, 2012)

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Theoretical models:

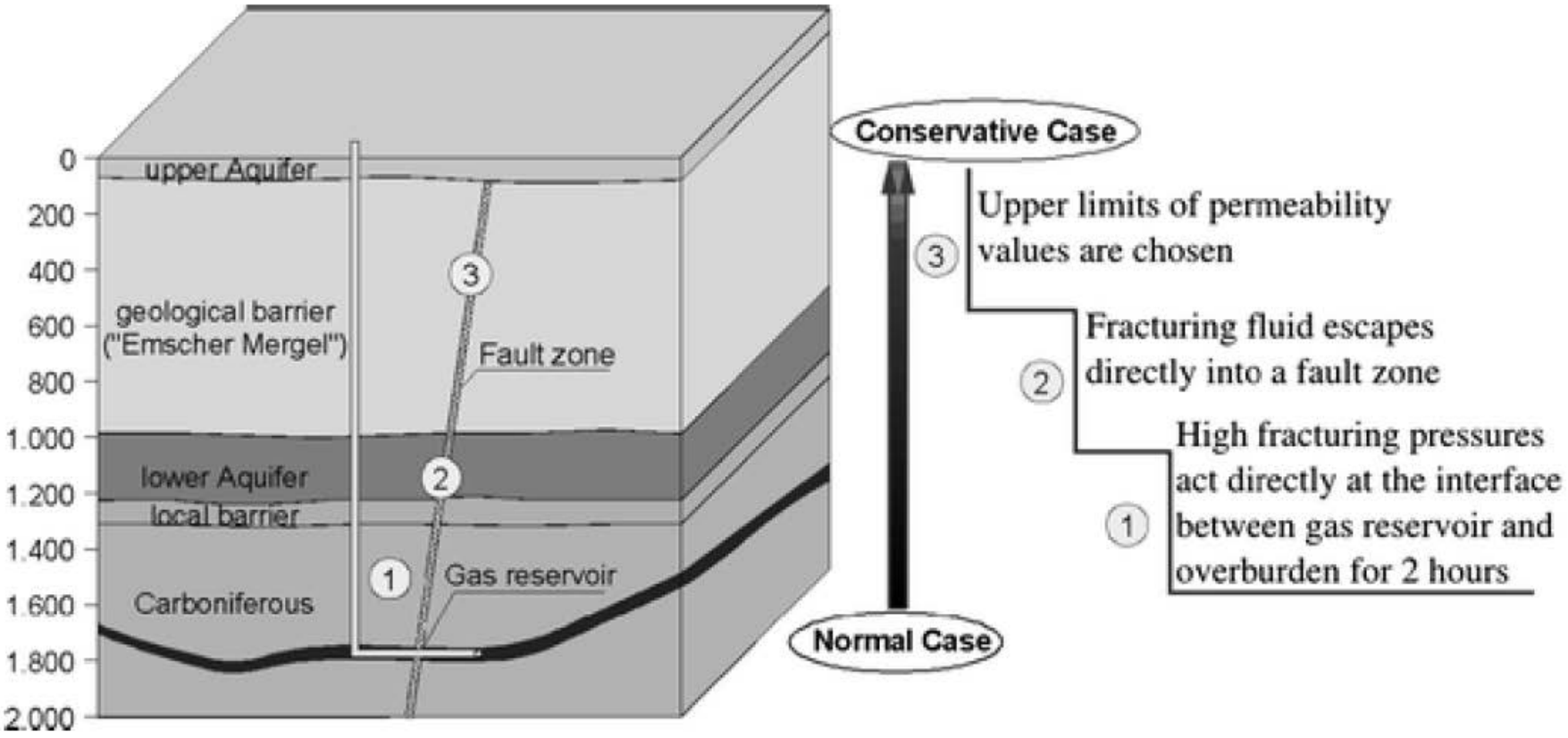

Fig. 4

Illustrative representation of the conservative assumptions made in Scenario 1 (shown here for the Münsterland Basin as an example)

Source: Kissinger et al., 2013. Hydraulic fracturing in unconventional gas reservoirs: risks in the geological system, part 2: Modelling the transport of fracturing fluids, brine and methane, Environmental Earth Sciences

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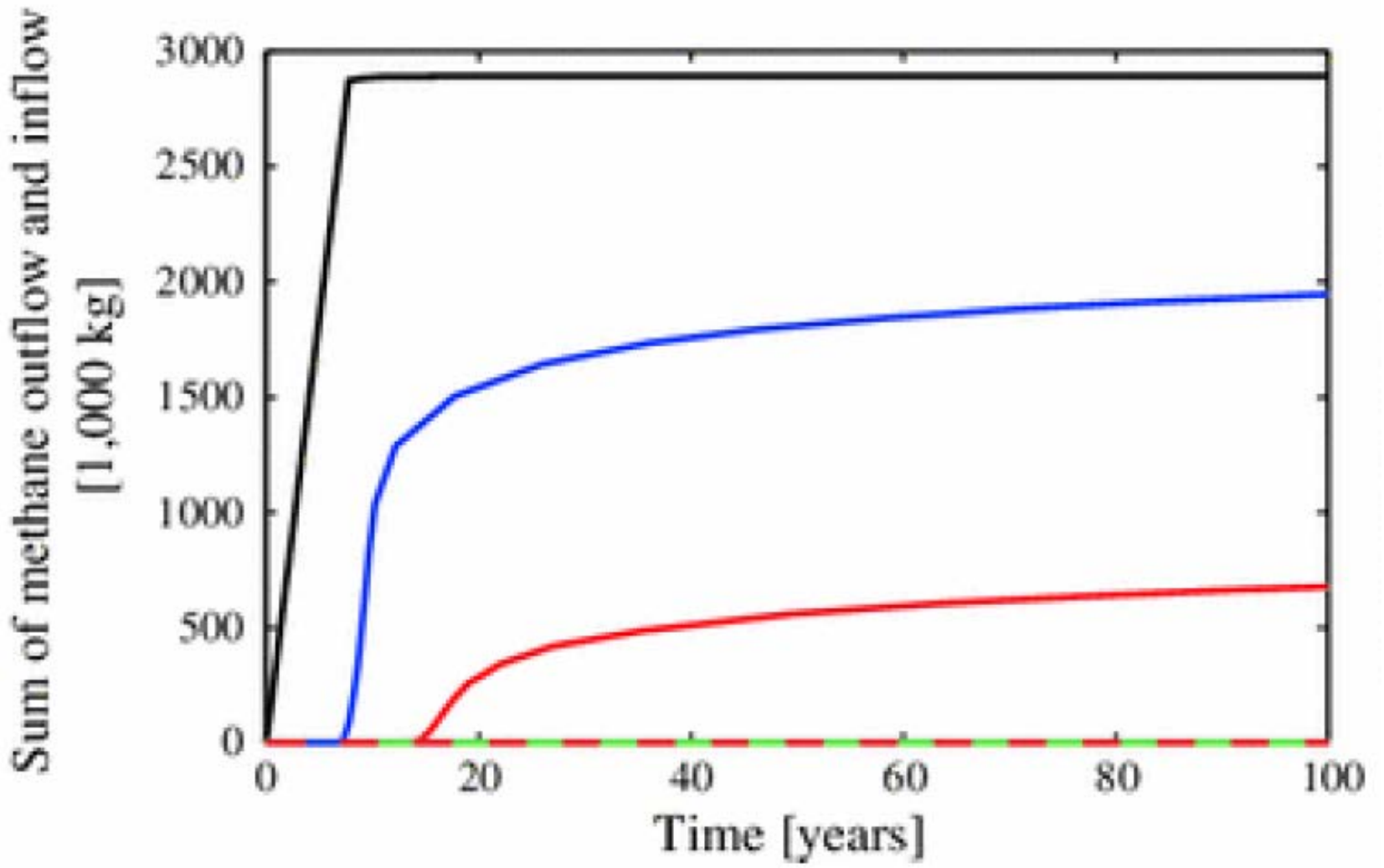
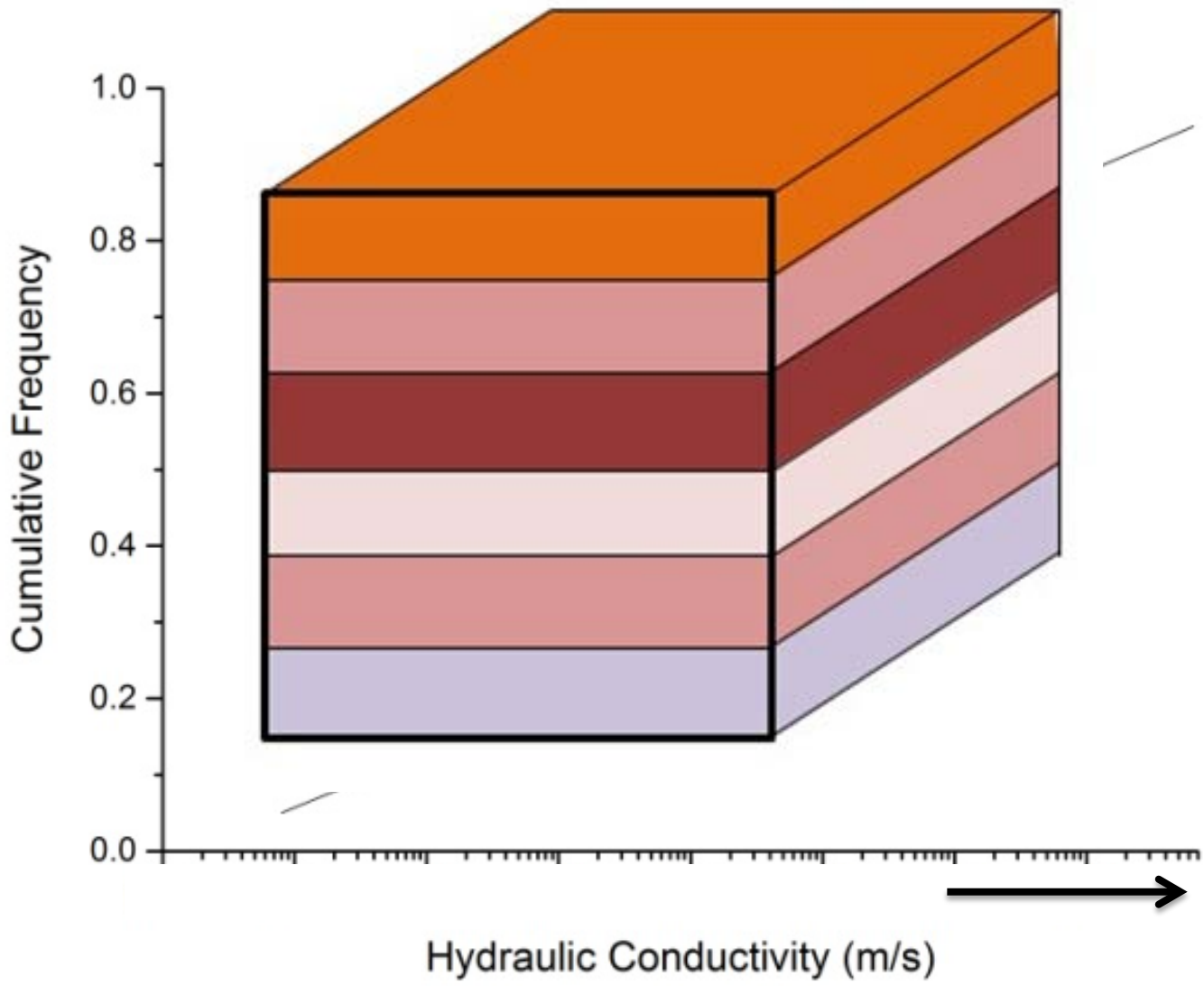


Analytical analysis:



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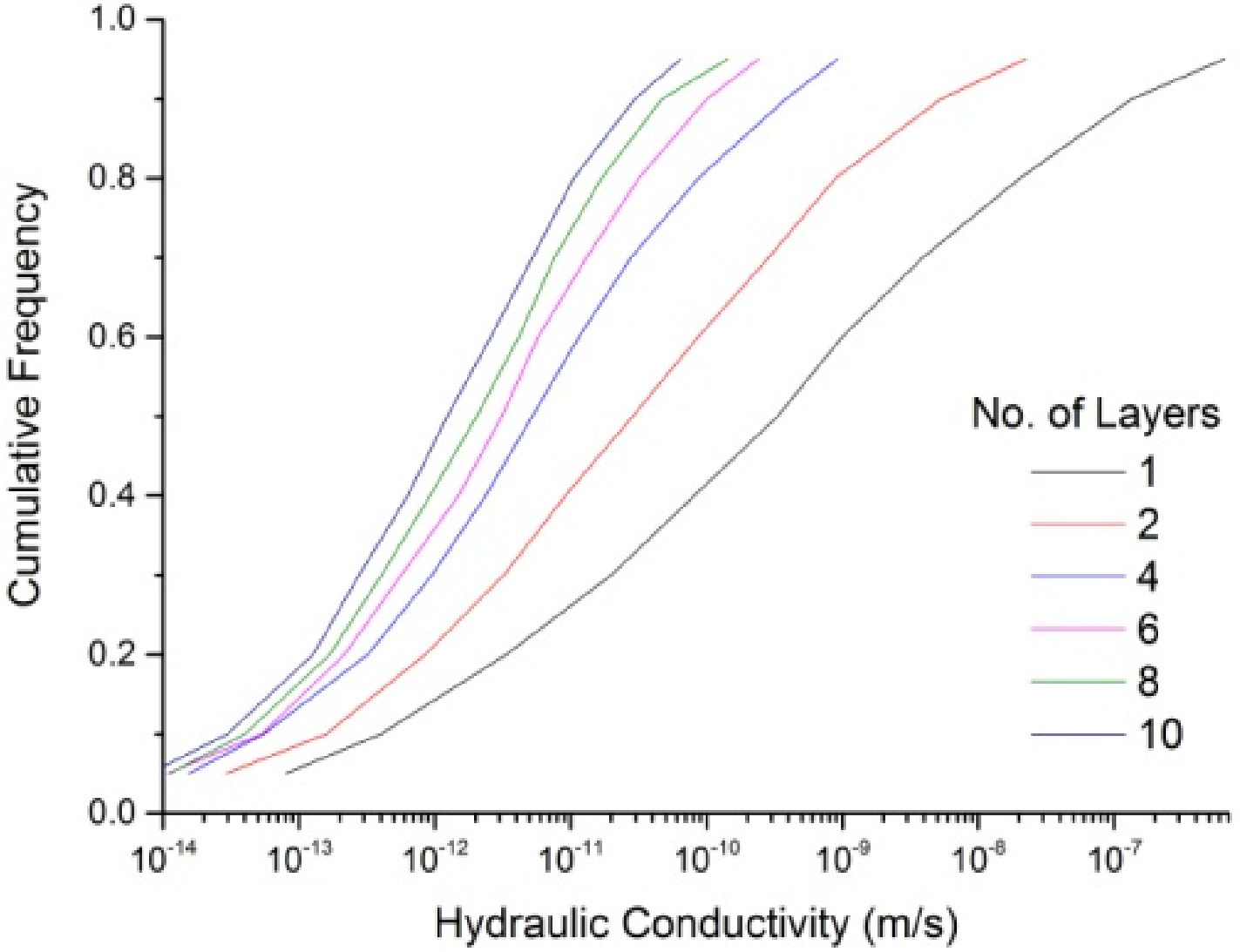

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Stay tuned!
Full report by the end of the year…