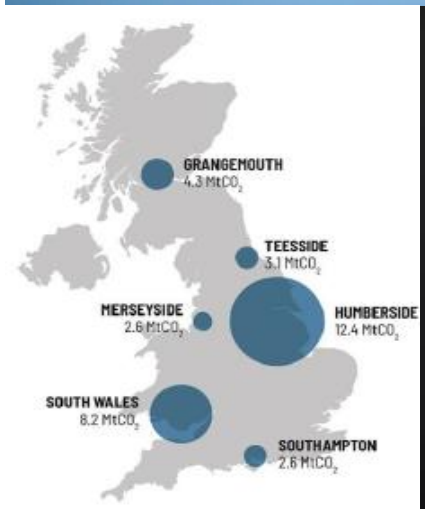
Northern Endurance Partnership

Optimising Regional Aquifer Models for NEP Expansion: Challenges and Insights



Carwyn Adler

bp, *on behalf of the Northern Endurance Partnership*

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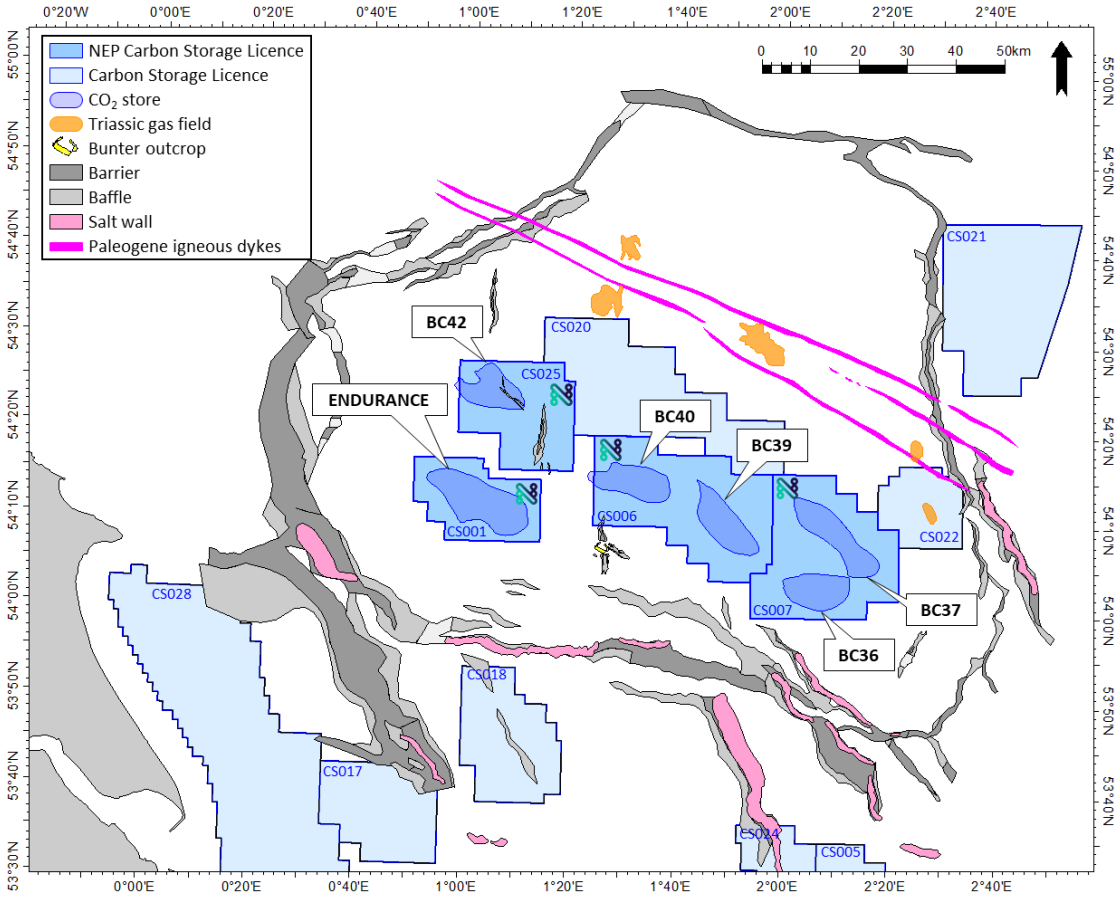
10th December 2025

Endurance CO_2 store and other licences

- **Northern Endurance Partnership (NEP)**
  - Transport & storage provider to East Coast Cluster (ECC)
  - Access to Endurance & expansion stores offshore UK Southern North Sea
- **CS001**
  - Endurance – Phase 1 development start-up from 2028 (4 Mt/yr for 25 yrs)
- **CS006**
  - BC39 and BC40 – under appraisal
- **CS007**
  - BC36 & BC37 – under appraisal
- **CS025**
  - BC42 – under appraisal
- **Other licences within Silver Pit Basin**
  - CS020 & CS022

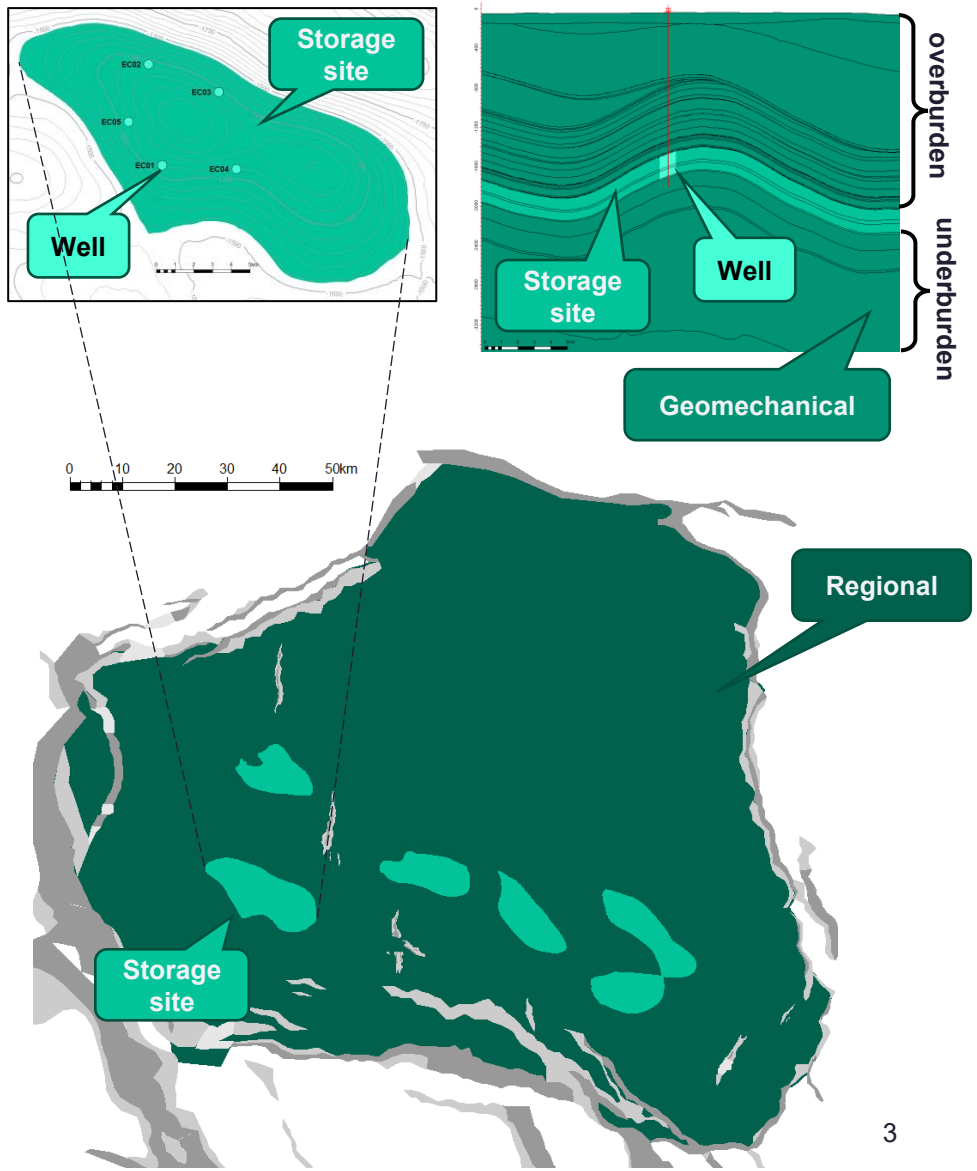


Modelling at different scales

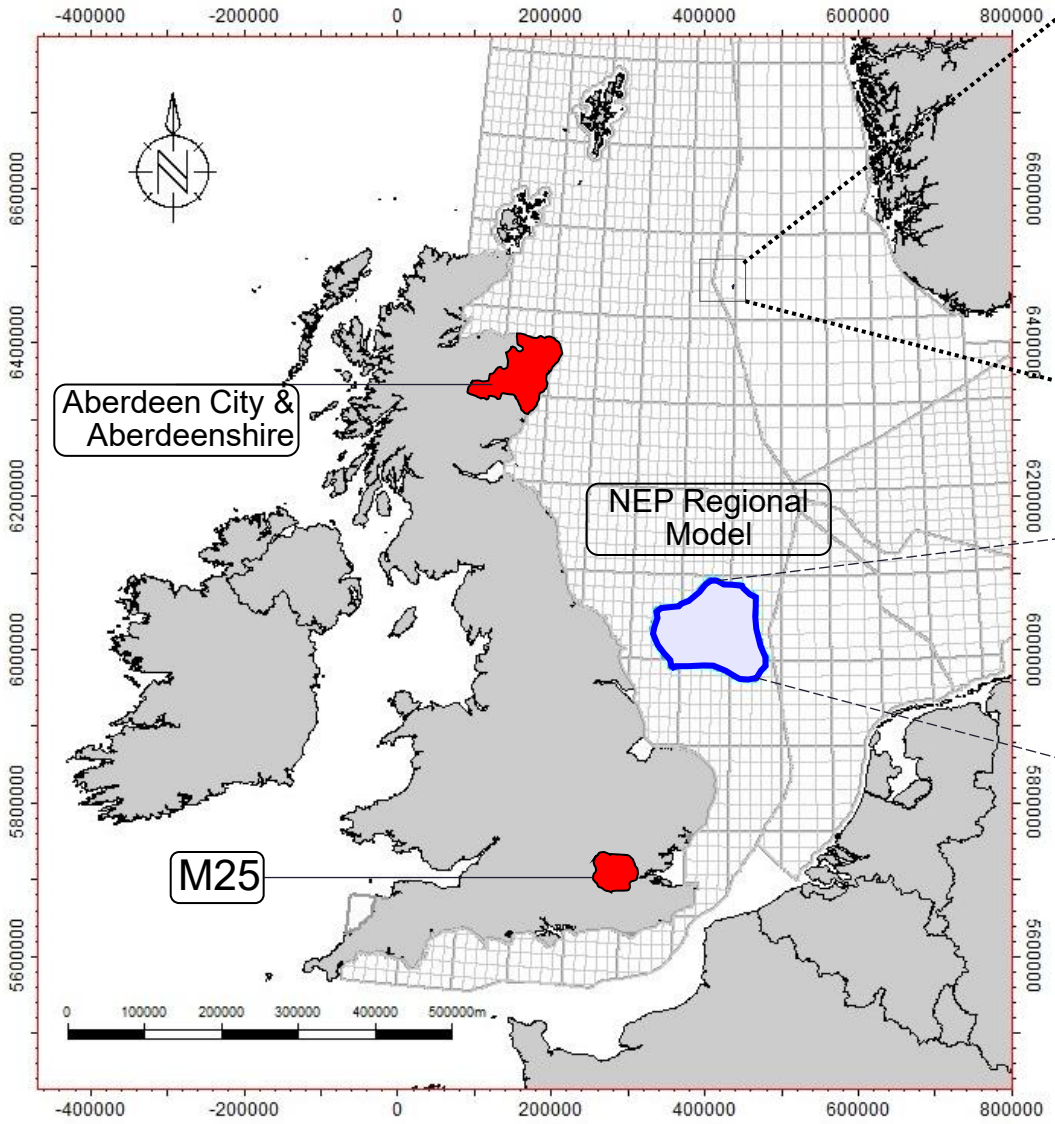
- **One model can't achieve everything**
  - Key to integrate models across scales and be mindful of their respective limitations

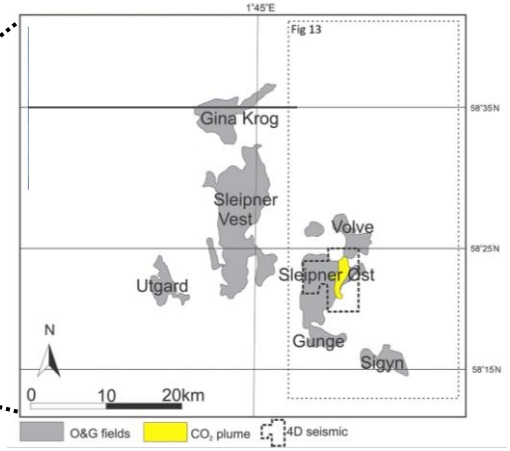
Increasing scale

Injectivity assessment	➢Well performance modelling ➢Thermal impacts on injectivity and seal stand-off ➢Halite precipitation impact and water flush mitigation
Storage site specific	➢CO_2 plume modelling ➢Storage capacity assessment ➢Well placement
Geomechanical and geochemical modelling	➢Potential leak pathways ➢Operating limits
Regional pressure prediction	➢Regional pressure development ➢Multi-store interference (Pressure headroom to inject)



The challenge of the regional scale





Adapted from Furre et al., 2024

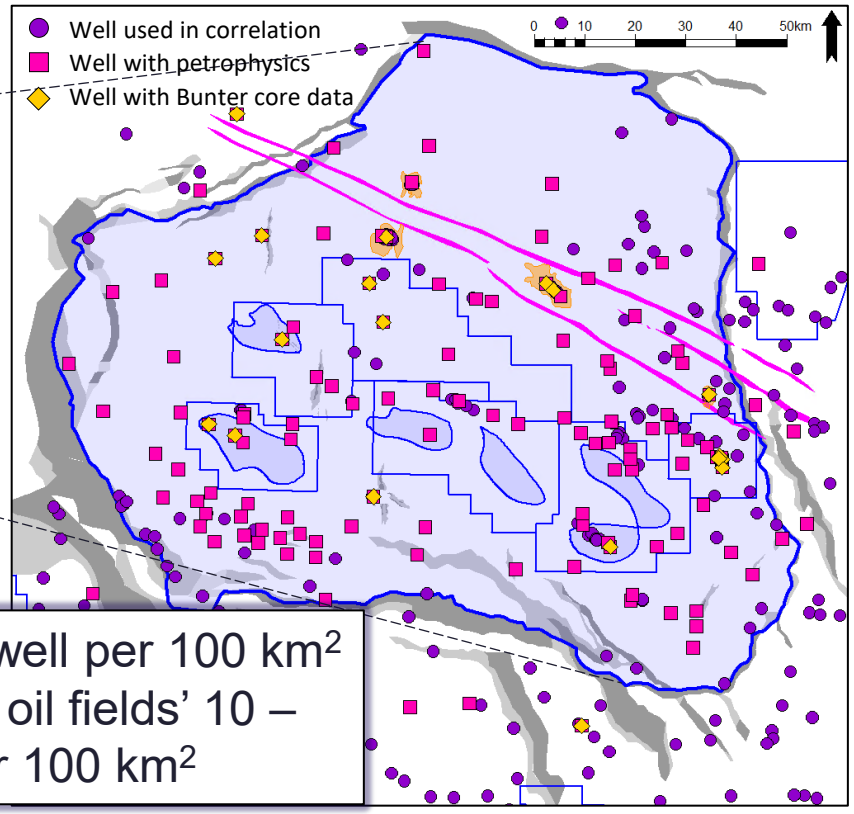
600 wells used in correlation

133 wells with petrophysical data

23 wells with core data

Limited dynamic data

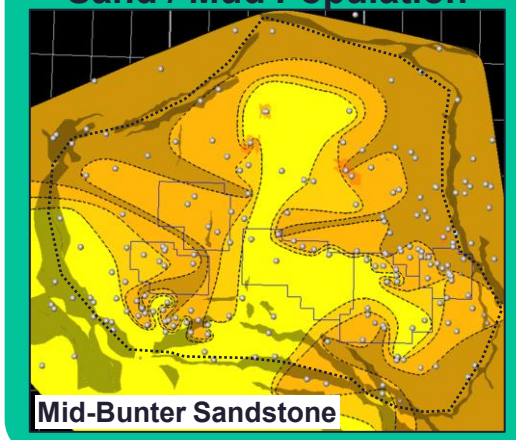
(Triassic gas fields, Endurance pressures)



Well density: NEP 1 well per 100 km^2 vs 'typical onshore oil fields' 10 – 100+ wells per 100 km^2

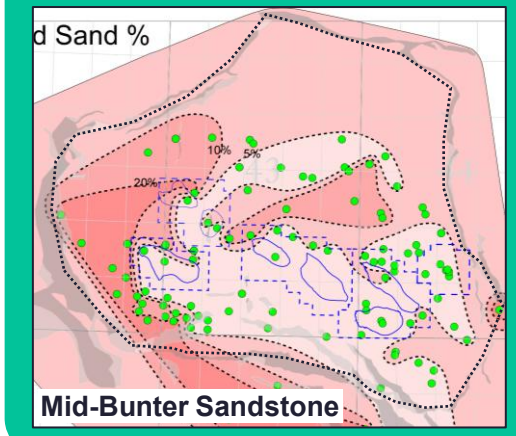
Static property population

Sand / Mud Population

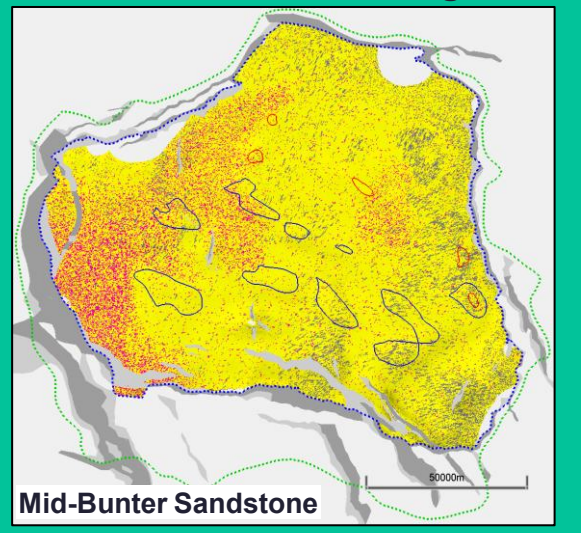


Multiple alternative static scenarios

Cement Population



Facies distribution in grid



- Sands
- Cem. Sands
- Mud-prone

Final Grid Design	
AOI	Silver Pit Basin
Orientation	NW–SE 115°
Cell XY	200m x 200m
Cell Z	110 layers (1.0 – 2.5 m)
Zones	Bunter Sst: 6 subzones
No. of cells	Total = 47.8 million Active = 33 million

Facies Petrophysical Property Population

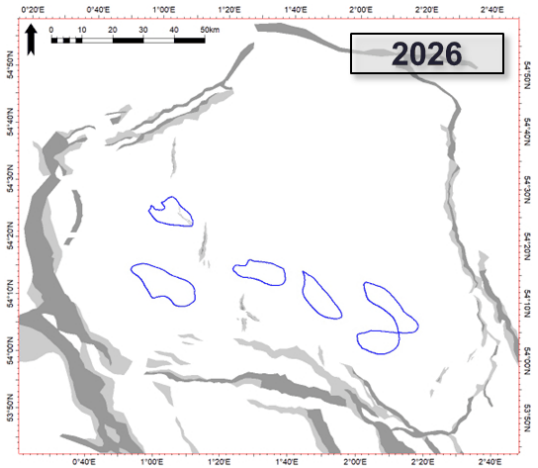
A continuous approach was taken for the petrophysical property population

- Porosity distribution
  - US Perm.
  - BC Perm.
  - DS Perm.
- Vclay distribution
- Net cut offs

Over 100 different static scenarios!

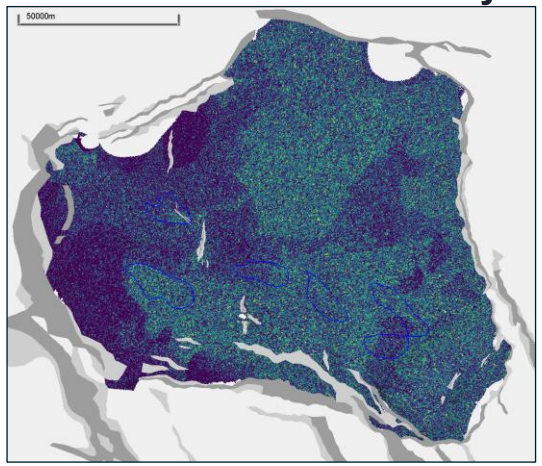
Impact of uncertainties

- Deterministic cases selected from the ensemble
- Objective functions are inversely correlated
- Move away from the notion of upside and downside cases

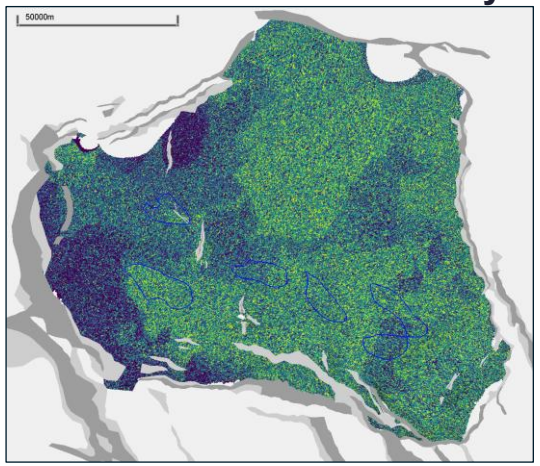


Pressure response for BC Perm

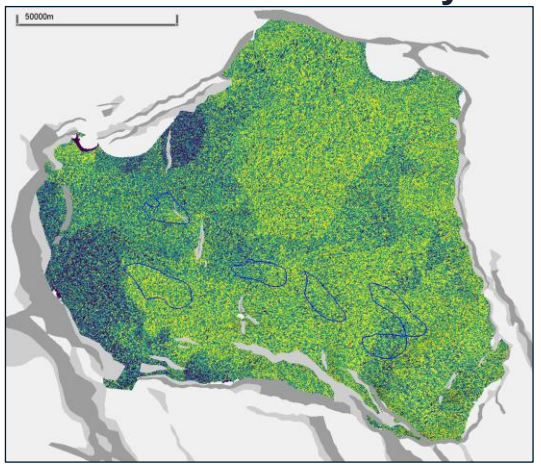
DOWNSIDE: Permeability

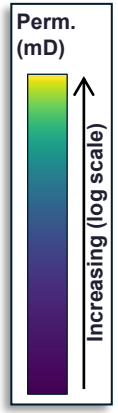


BASE CASE: Permeability

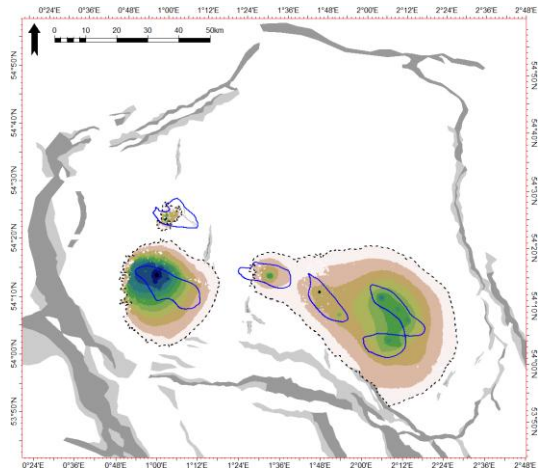


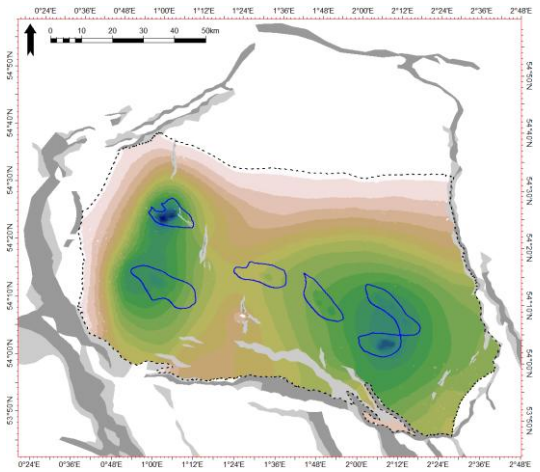
UPSIDE: Permeability

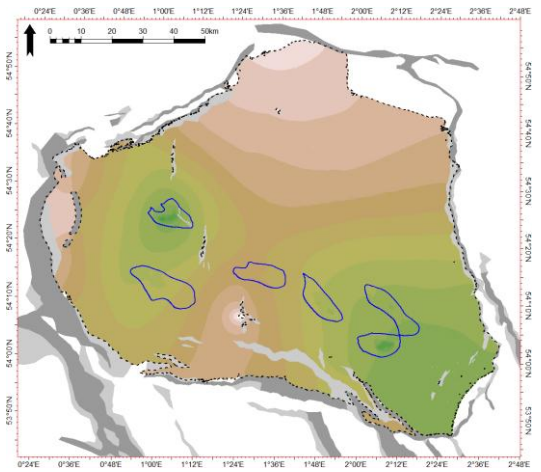




Pressure Response (2055)





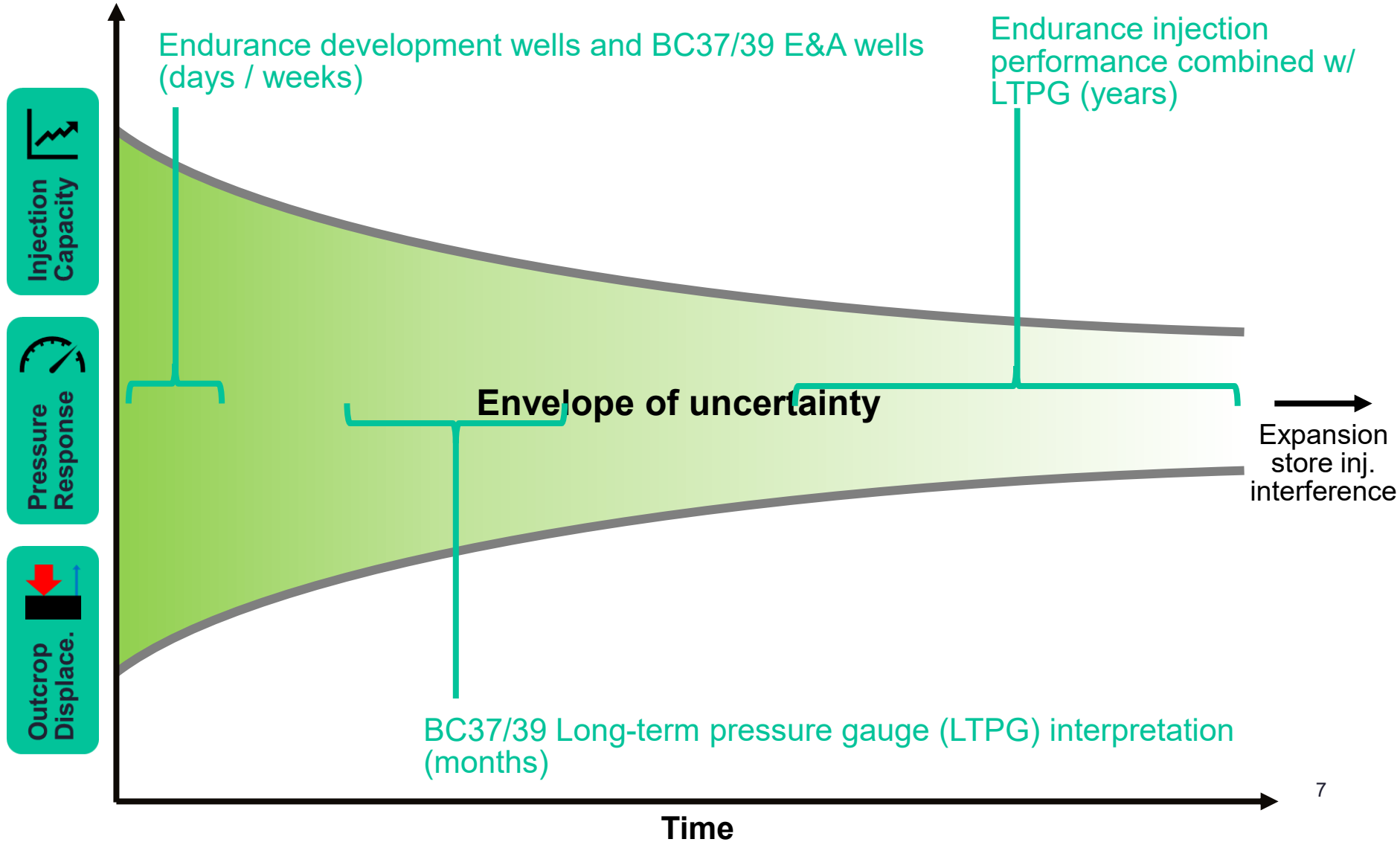


Higher localised pressure

More pressure interference

How do we calibrate the model?

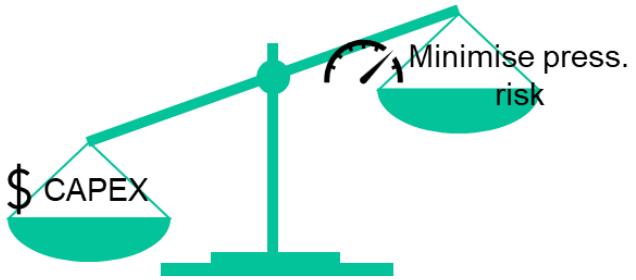
- The same broad uncertainty ranges applied to the entire model
- Global approach limits capability to achieve good localised dynamic match – **not objective of model**
- Permeability and aquifer connectivity are fundamental uncertainties influencing pressure dissipation
- **Data acquisition will be key to narrowing wide range**



Multi-store development optimisation

Challenges

- Competing business objectives at play so what is optimum?



- Large number of possible variables (e.g. no. wells, well rates) and many combinations

Fixing all variables and only varying well selection…

Given 31 well location options

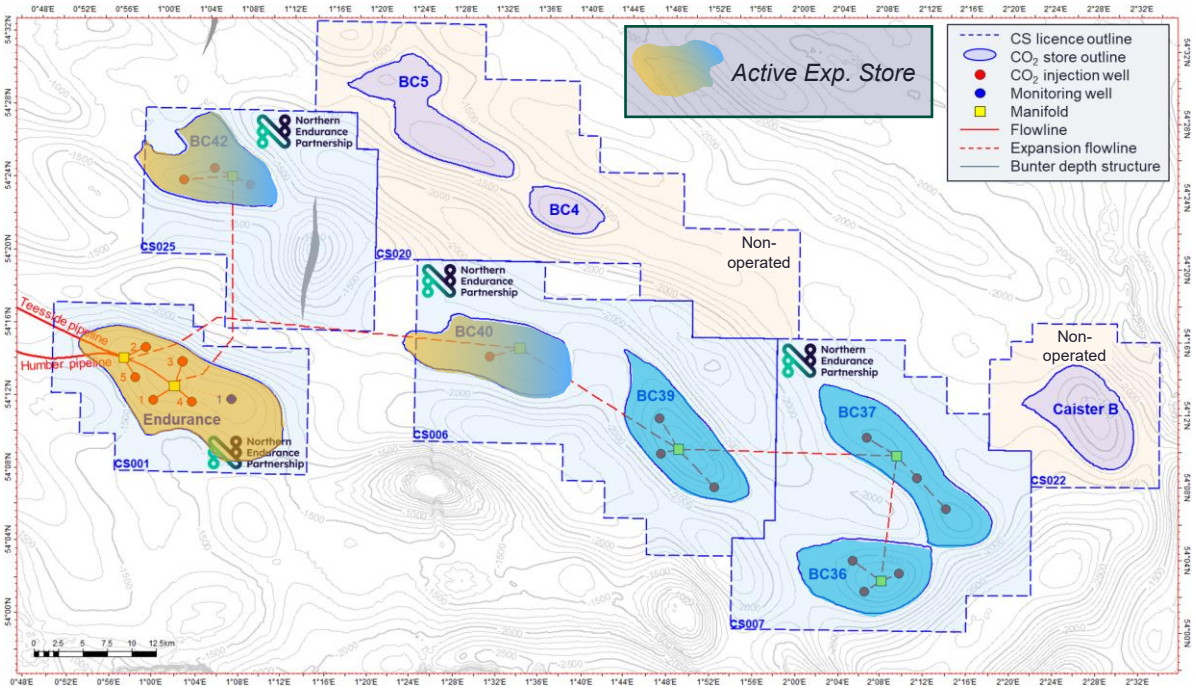
Varying just 6 wells = ~ 600k possible combinations

Solution

- Pragmatic thematic approach required e.g.
  - Minimise pressure risk
  - Minimise CAPEX

..but many other business objectives considered

- Consider a limited set of combinations within those themes



Conclusions

- **Regional model is important tool for forecasting pressure interactions but highly uncertain even when using all available data**
- **Permeability and aquifer connectivity are fundamental uncertainties influencing pressure dissipation**
- **Dynamic data will be key to advancing understanding of the aquifer and narrowing uncertainty ranges**
  - Additional dynamic data could enable a move away from global model population approach to a more localised property refinement
- **Regional model will be used for the optimisation of store developments**
  - Careful consideration will be required to balance the competing business objectives
- **Boundary conditions of future expansion storage site specific models to be matched to the results of the regional model**