



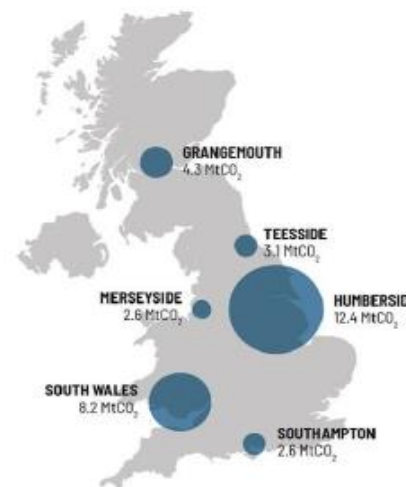
# Sub-Regional CO<sub>2</sub> Storage Development: Selecting multiple storage sites to support the decarbonization of the UK's East Coast

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bp, *on behalf of the Northern Endurance Partnership*

CO<sub>2</sub> Storage Conference, Aberdeen

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# Overview

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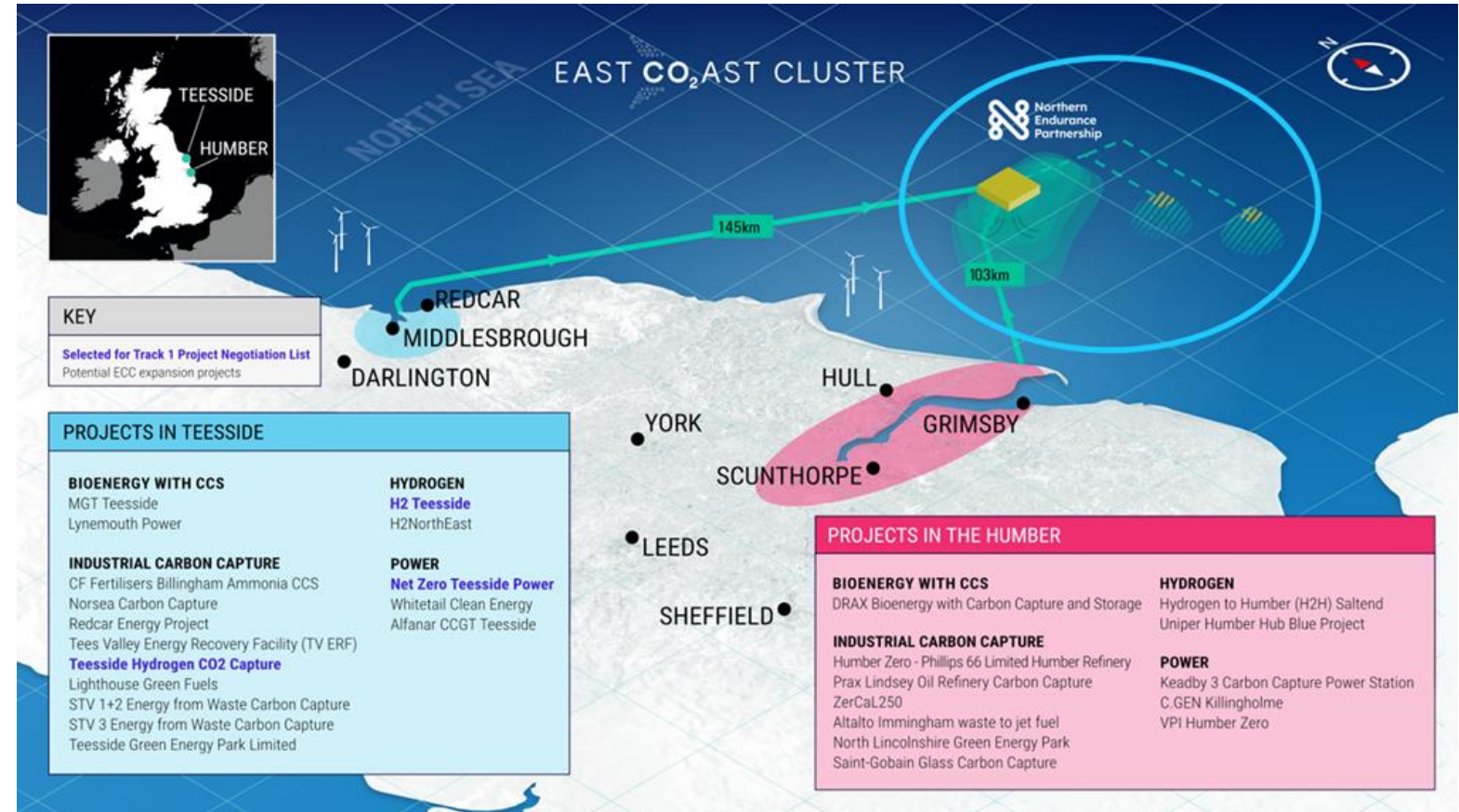


- East Coast Cluster (ECC) & the Northern Endurance Partnership (NEP)
- Endurance and expansion sites
- Storage site considerations
- Modelling approaches
- Development plan
- Summary

# East Coast Cluster & Northern Endurance Partnership



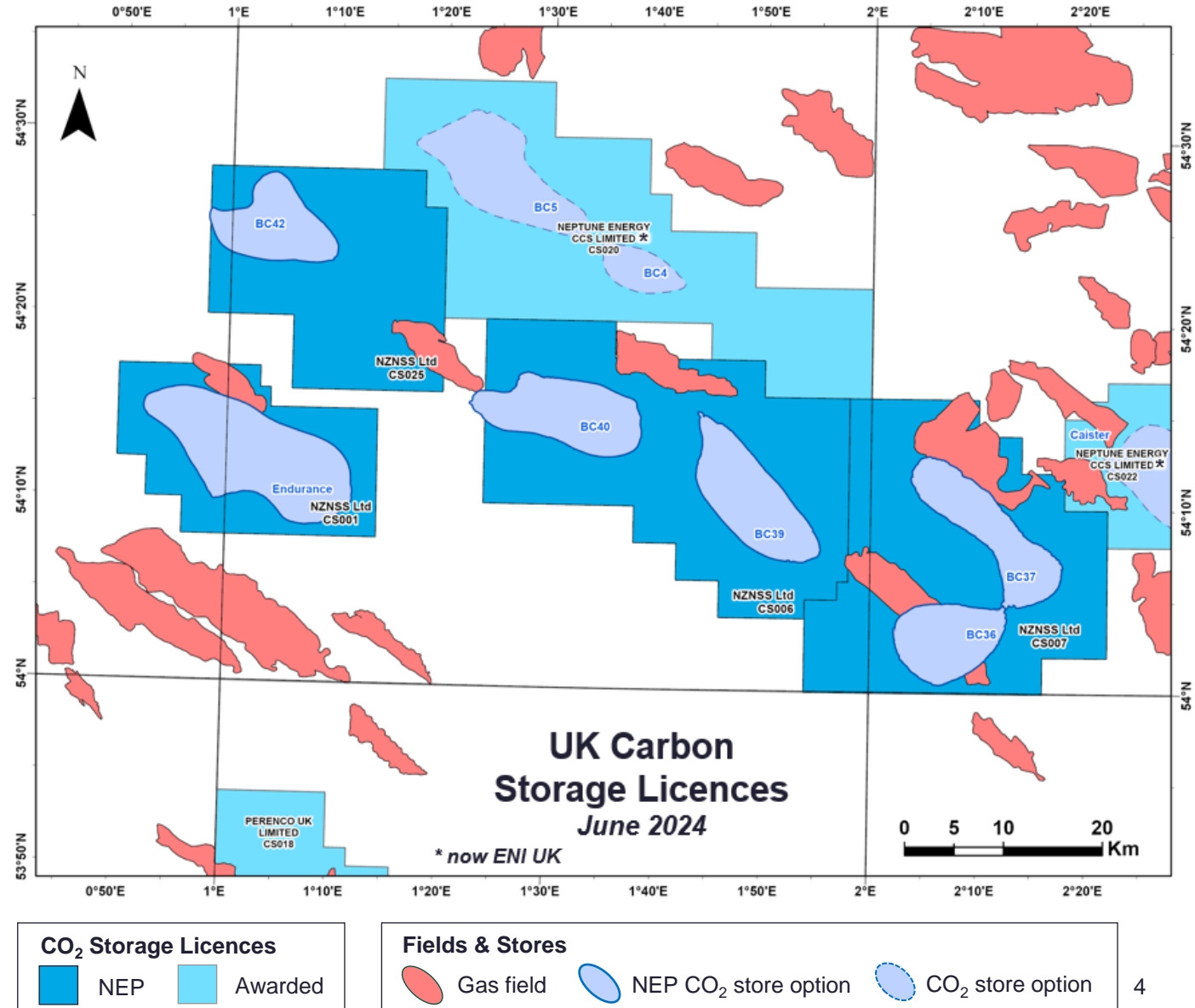
- The **East Coast Cluster (ECC)** is a single, unified CCS cluster
  - Serving industrial regions Teesside & Humber
  - Selected as Track-1 cluster by UK government
- Underpinned by the **Northern Endurance Partnership (NEP) IJV**
  - bp, Equinor, and TotalEnergies
  - Common infrastructure to transport CO<sub>2</sub> from emitters in Teesside & Humber
  - Access to Endurance saline aquifer CO<sub>2</sub> store
  - Offers secure and scalable offshore storage in the UK Southern North Sea



# Endurance and expansion sites



- NEP holds 4 carbon storage licences in the Southern North Sea
- **Endurance Phase 1 (CS001)**
  - CO<sub>2</sub> injected into Triassic-age Endurance saline aquifer store, via 2 subsea manifolds with 5 injection wells and 1 monitoring well
  - Injection rate of 4 Mt/yr for 25 years (100 Mt total; ~0.8 Mt/yr per well)
  - First commercial operations from 2027
- **Future expansion**
  - Potential expansion at Endurance or new sites based on dynamic appraisal
  - Key to understand the impact of increased injection on the CO<sub>2</sub> plume and pressurisation within the area of interest (AOI)



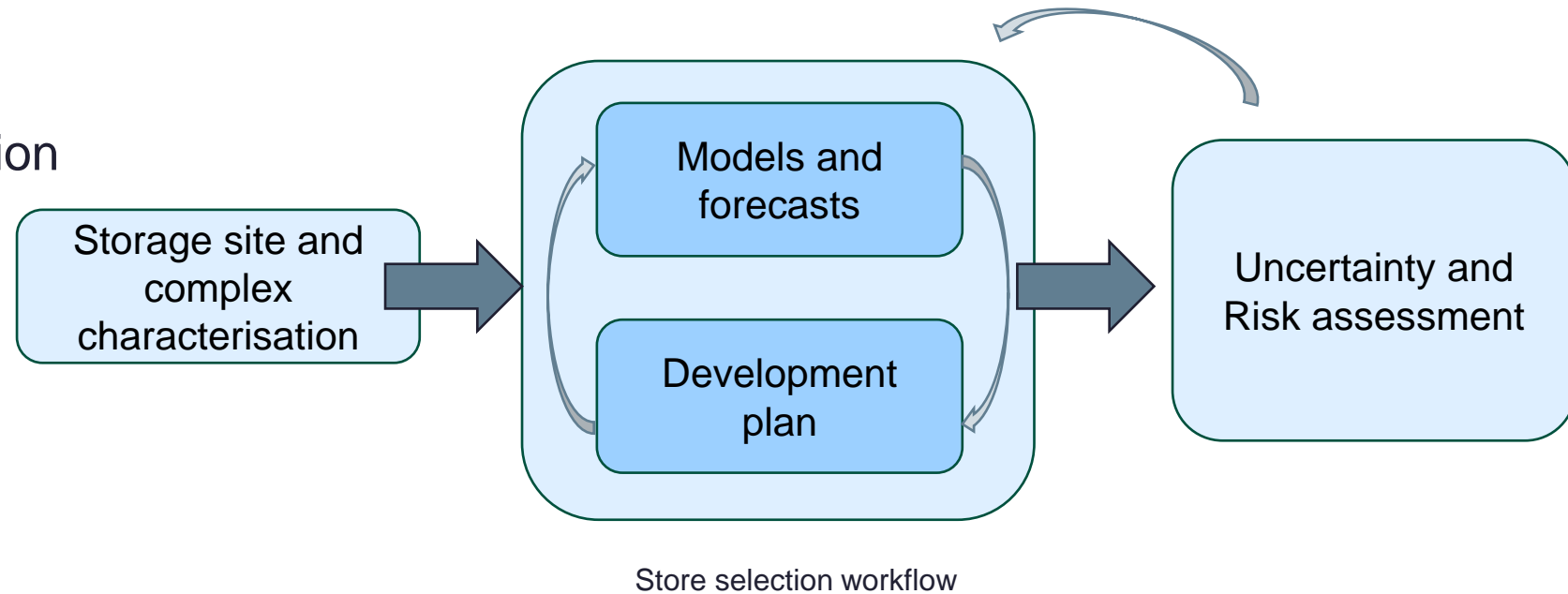
# Storage site selection considerations



- **Several considerations for selecting a viable storage site**

- **Subsurface**

- Storage Capacity
  - Reservoir characterisation
  - Aquifer connectivity
- Injectivity
- Containment
  - Storage complex
  - Legacy wells



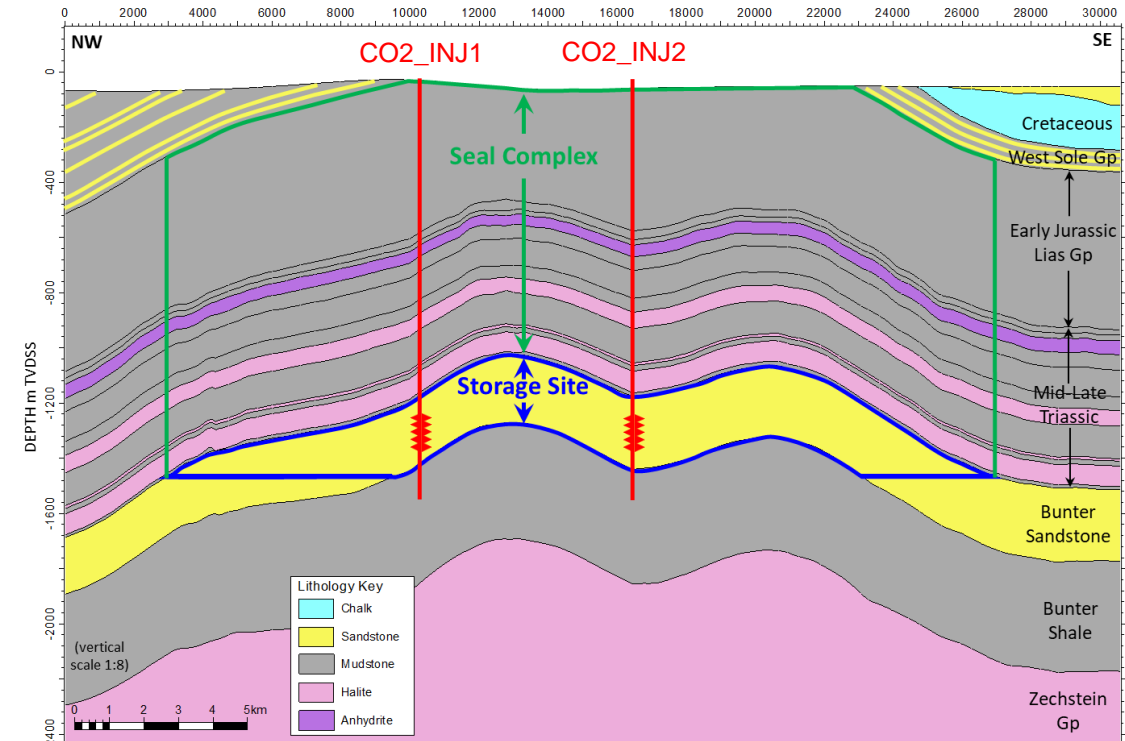
- **Surface**

- Shallow hazards
- Surface features (e.g. water depth, seabed stability, shared real estate with other seabed users)
- Environmental restrictions

# Site selection considerations – Capacity and Containment

Storage site and complex characterisation

- **Seal and reservoir characterisation**
  - Overburden characterisation, reservoir heterogeneity, quality and compartmentalisation
  - Operating limits at the crest and flank based on seal characterisation and geomechanical data
- **Wider aquifer connectivity**
  - Development concept relies on understanding of hydraulic connectivity and pressure dissipation into surrounding aquifer
  - Permeability is a key control of the store's dynamic capacity potential
- **Well placement**
  - Stand-off from the structural crest and lowest closing contour
  - Distributed layout mitigates against field heterogeneities or on-structure compartmentalisation



# Site selection considerations - Injectivity

Storage site and complex characterisation



- **Seal and reservoir characterisation**

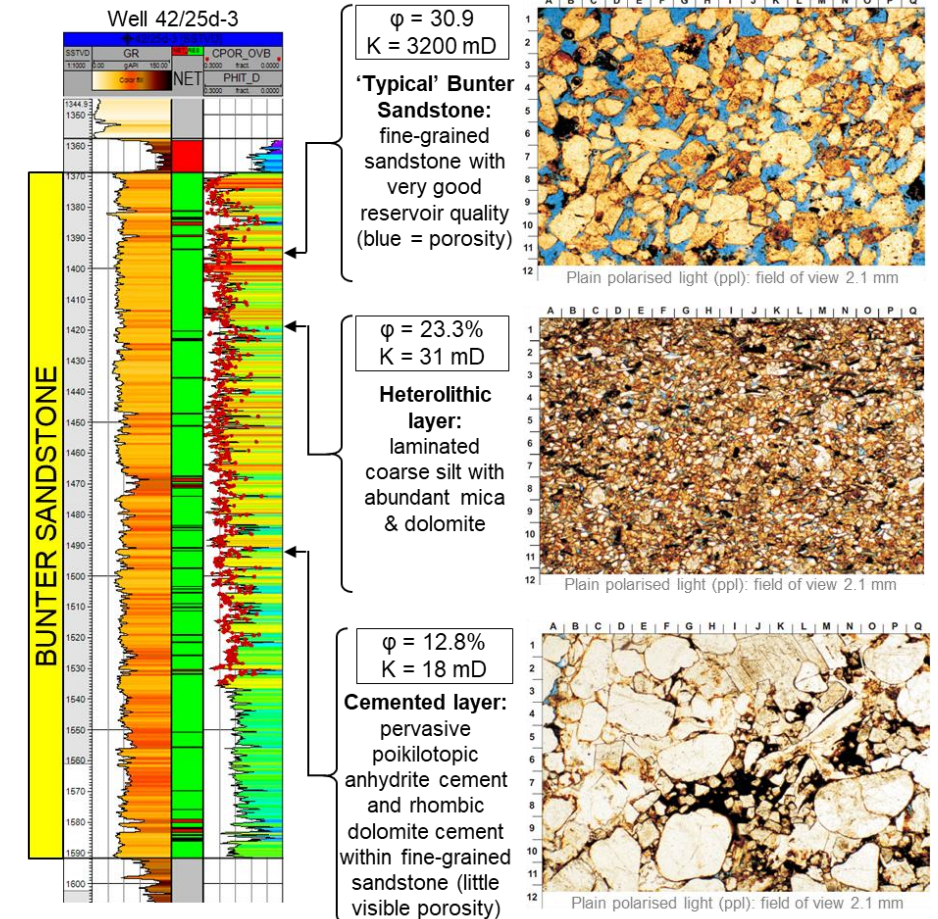
- Reservoir heterogeneity and quality
- Operating limits at the well based on seal characterisation and geomechanical data

- **Fluid characterisation**

- Hypersaline water, injectivity performance may be impacted due to potential halite precipitation
- Reservoir heterogeneity could limit efficient propagation of the dry-out zone away from the well

- **Well placement**

- Maximise perforation interval to achieve largest flow capacity (perm-thickness)
- Stand-off from the base of the seal to mitigate the impact of cooling and risk of thermally-fracturing the caprock



# Modelling at different scales



- Different scales and physical mechanisms need to be integrated to support storage site selection and performance prediction

Increasing scale

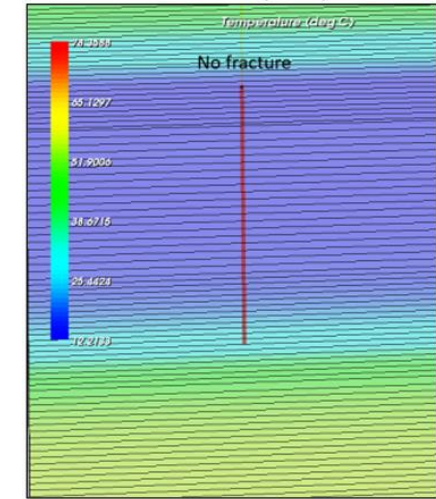
## ➤ Injectivity assessment

- Well performance modelling
- Thermal impacts on injectivity and seal stand-off
- Halite precipitation impact and water flush mitigation

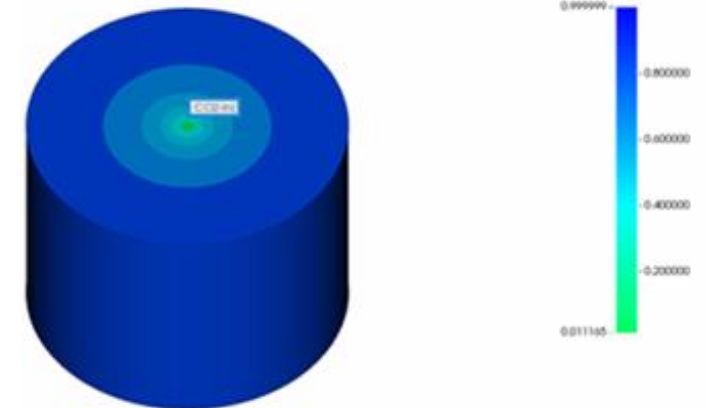
➤ Storage site-specific CO<sub>2</sub> plume modelling

➤ Geomechanical and geochemical modelling

➤ Regional pressure prediction



Thermal fracture modelling



Mechanistic near wellbore model used to model the coupled transport, mutual solubility and geochemical effects



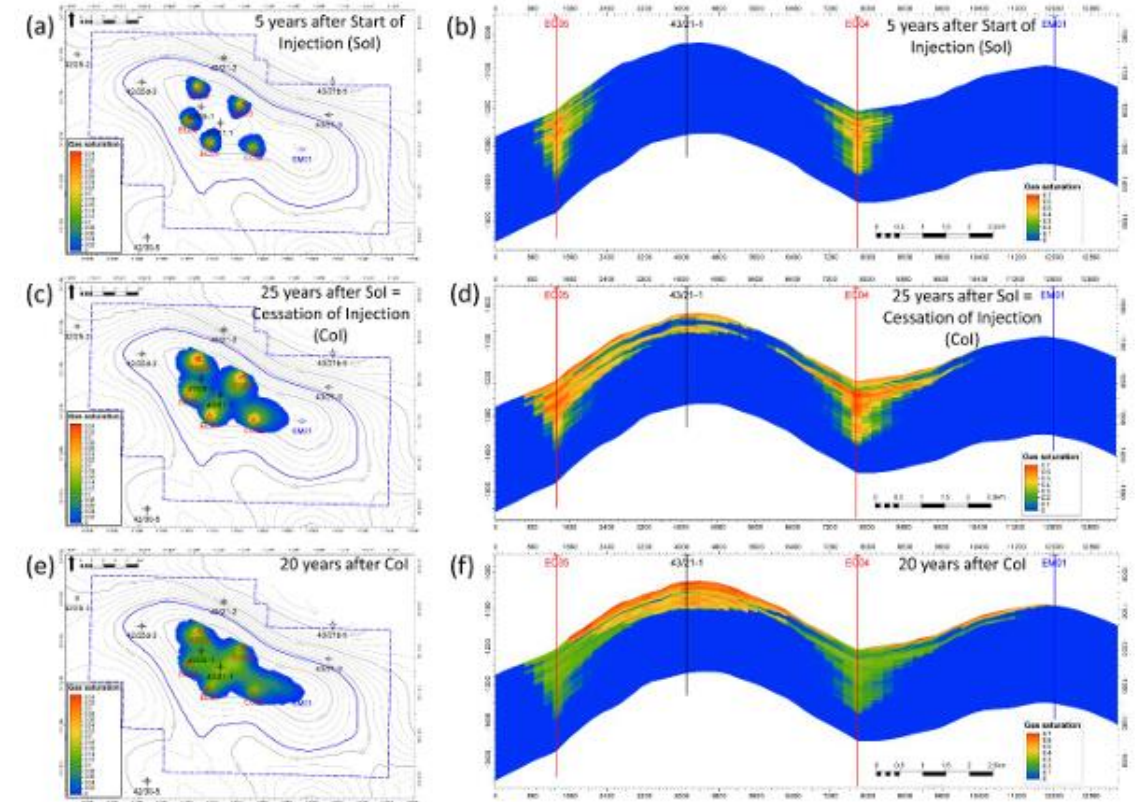
# Modelling at different scales



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Increasing scale

- Injectivity assessment
- **Storage site-specific**
  - CO<sub>2</sub> plume modelling
  - Storage capacity assessment
  - Well placement
- Geomechanical and geochemical modelling
- Regional pressure prediction



Bunter sandstone average CO<sub>2</sub> saturation after cessation of injection at Endurance

Gibson-Poole et al., 2024

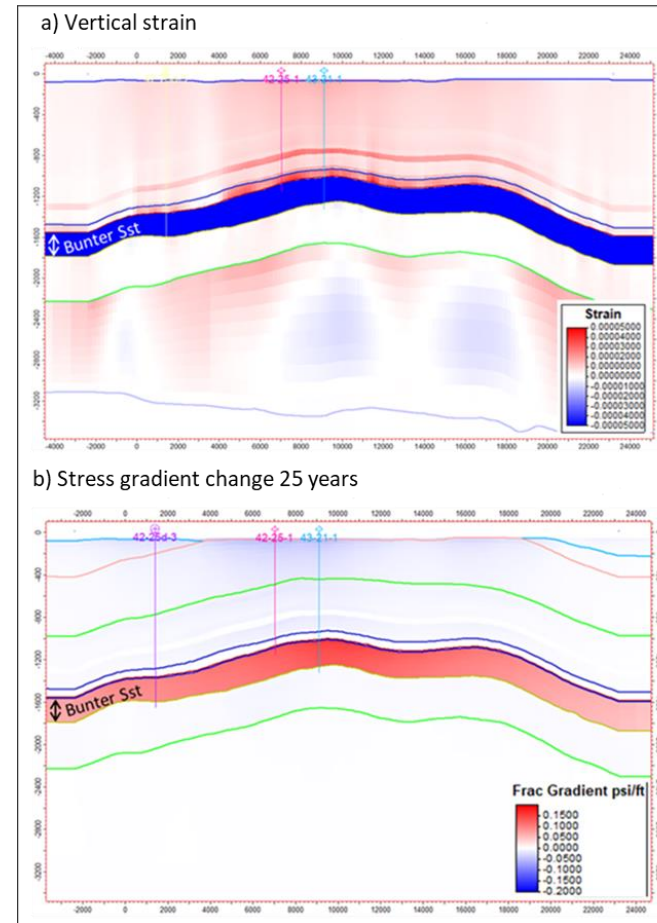
# Modelling at different scales



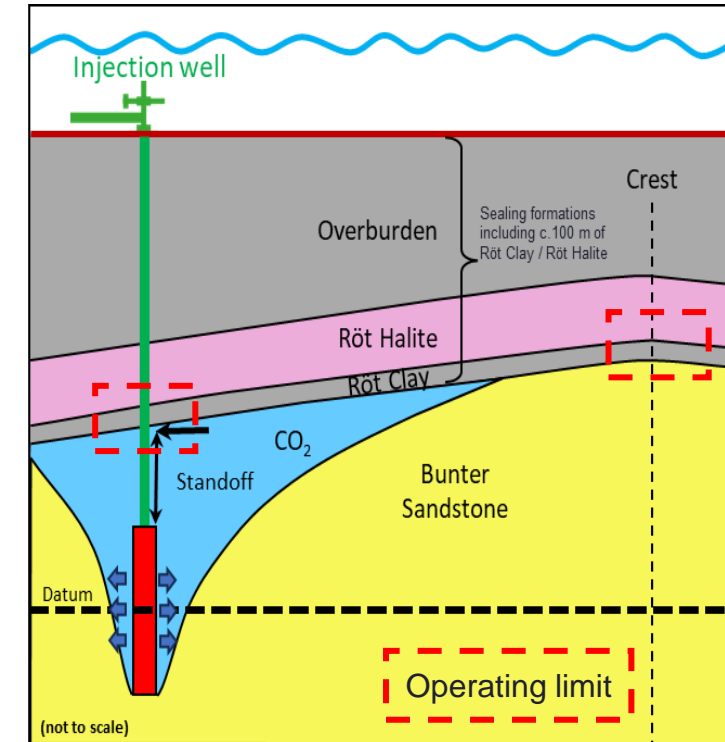
- Different scales and physical mechanisms need to be integrated to support storage site selection and performance prediction

Increasing scale

- Injectivity assessment
- Storage site-specific
- **Geomechanical**
  - Potential leak pathways
  - Operating limits
- Regional pressure prediction



Geomechanical model : (a) vertical strain property; and (b) change in stress gradient from start of injection to cessation of injection (25 years).



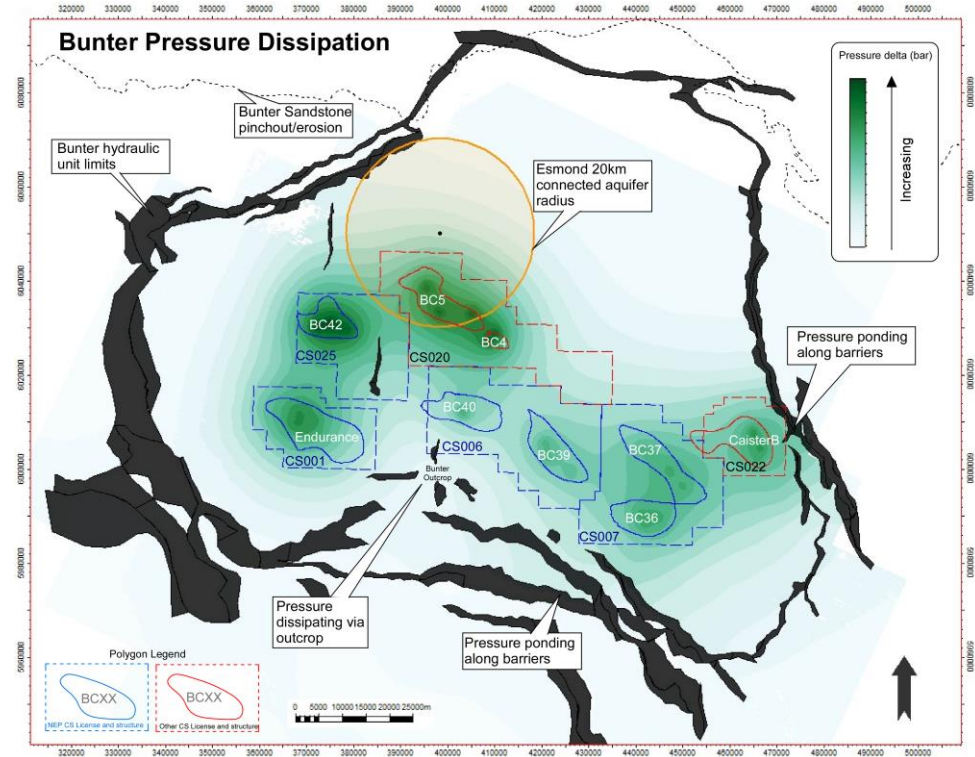
Geomechanical modelling feeds into well and reservoir operating limits



- Different scales and physical mechanisms need to be integrated to support storage site selection and performance prediction



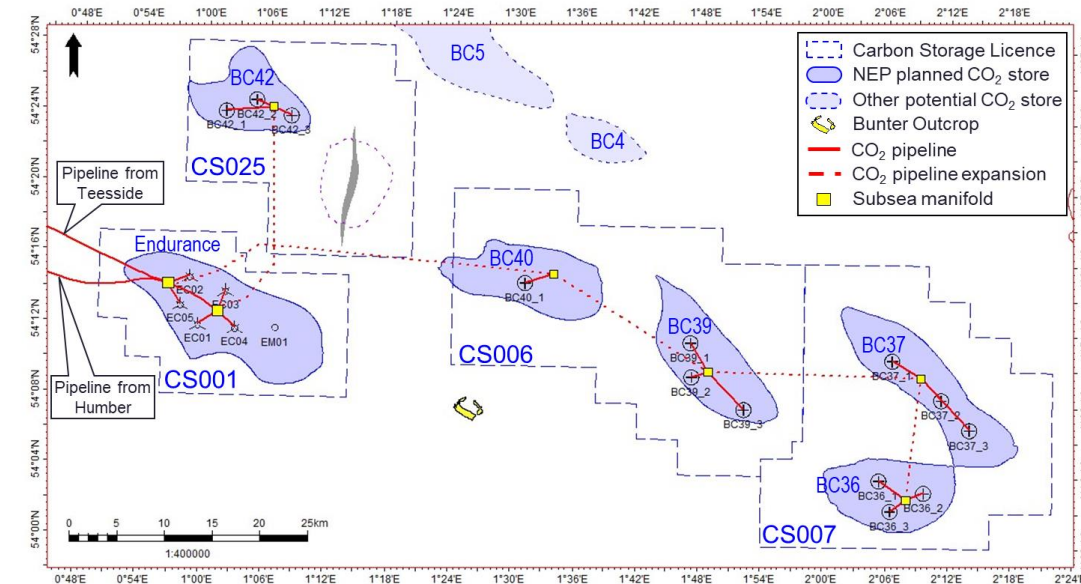
- Injectivity assessment
- Storage site-specific
- Geomechanical and geochemical modelling
- **Regional pressure prediction**
  - Regional pressure development
  - Multi-store interference (Pressure headroom to inject)
- **One model can't achieve everything**
  - Key to integrate models across scales and be mindful of their respective limitations



Regional modelling of pressure development across the aquifer. Key model to test multi-store development and store capacities



- NEP has used the presented approaches to assess
  - Subsurface uncertainties and related key risk scenarios
  - Alternative realisations and development scenarios
- Risk and uncertainties
  - Reservoir quality distribution across storage sites
  - Well injectivity
  - Regional pressurization evolution and interactions
- The multi-store development plan aims to deliver a portfolio of potential storage sites whilst
  - Reducing uncertainties via appraisal activity and dynamic testing
  - Distributed well and different storage sites to mitigate against uncertain static and dynamic outcomes

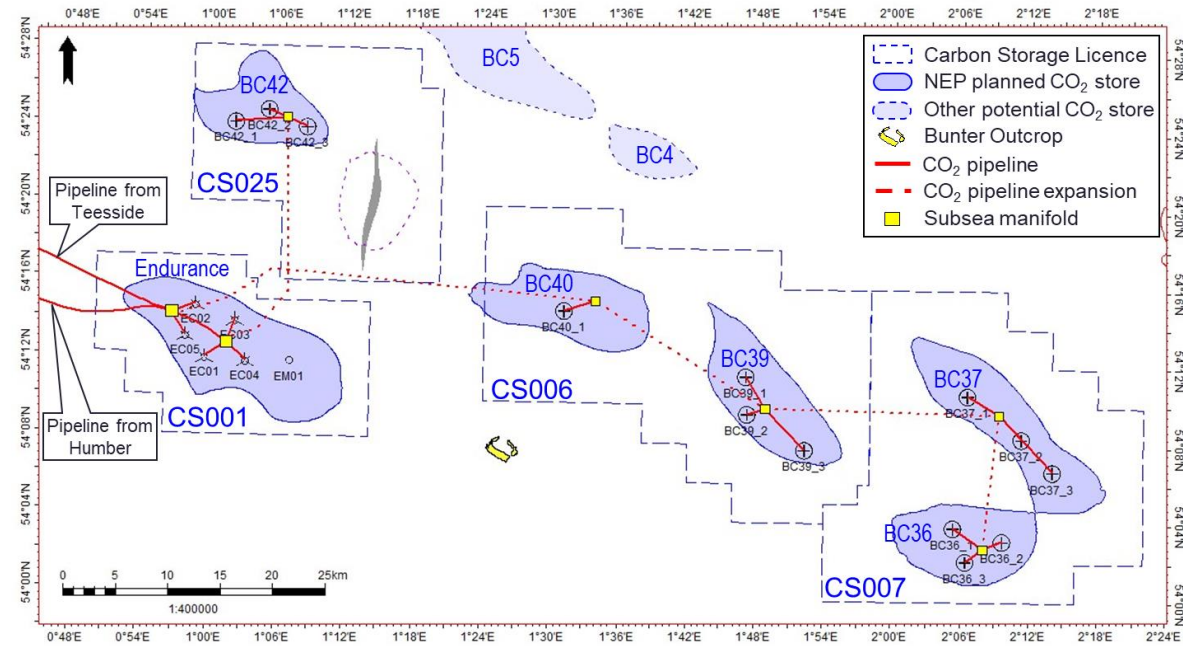


Notional concept for expansion: A multi-store sub-regional development (notional well locations)

# Summary



- Northern Endurance Partnership (NEP) enables the East Coast Cluster by providing the transport and secure offshore storage at Endurance for industrial emitters in Teesside and Humber regions
- The NEP carries a portfolio of potential storage sites to support UK's decarbonisation plans beyond 2030
  - Technical assessment will be matured via appraisal data collection and integration of dynamic understanding
- Continued modelling capability advancement will help support effective storage site selection and associated assessment of uncertainty and risk management



Notional concept for expansion: A multi-store sub-regional development (notional well locations)

# Acknowledgements

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Northern Endurance Partnership:



## Questions?