British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

Developing storage sites prior to deployment

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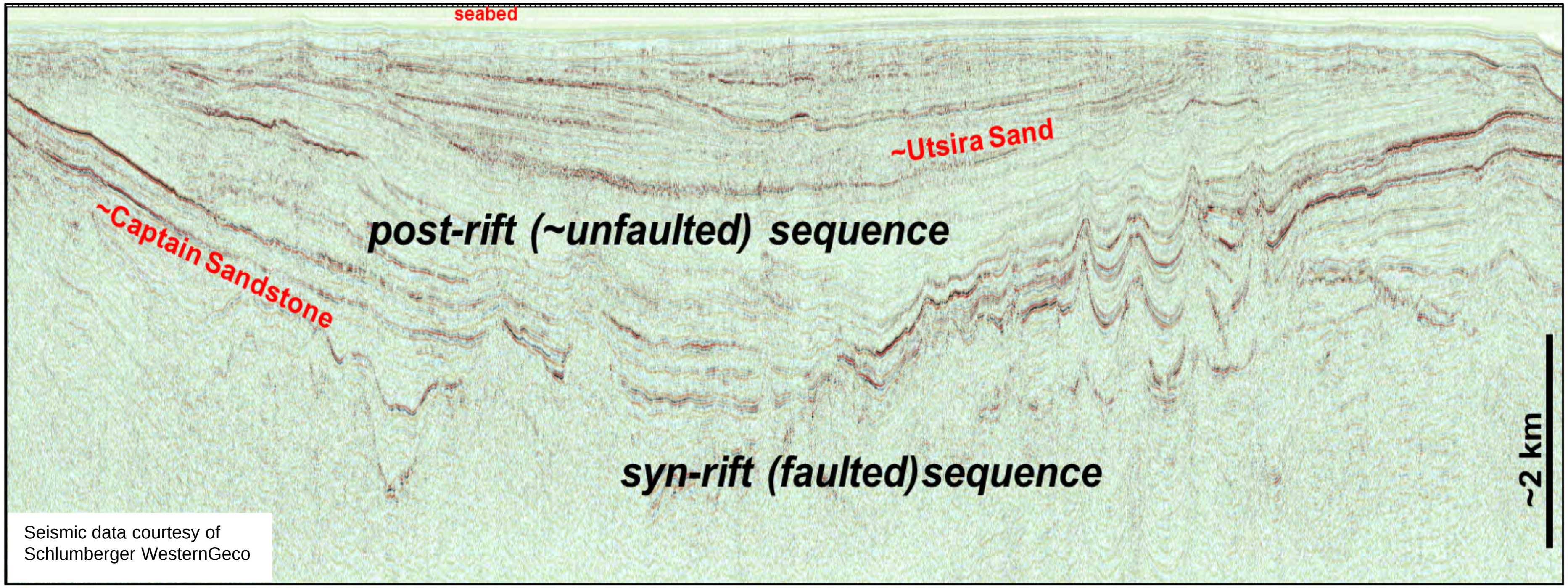
Talk outline

- What are the options for CCS from a storage perspective?
  - TCE Site portfolio work by BGS
- Where should we focus?
- How do we create confidence in storage?
- Next steps

A PORTFOLIO OF STORAGE SITES

Storage Central North Sea

Central North Sea



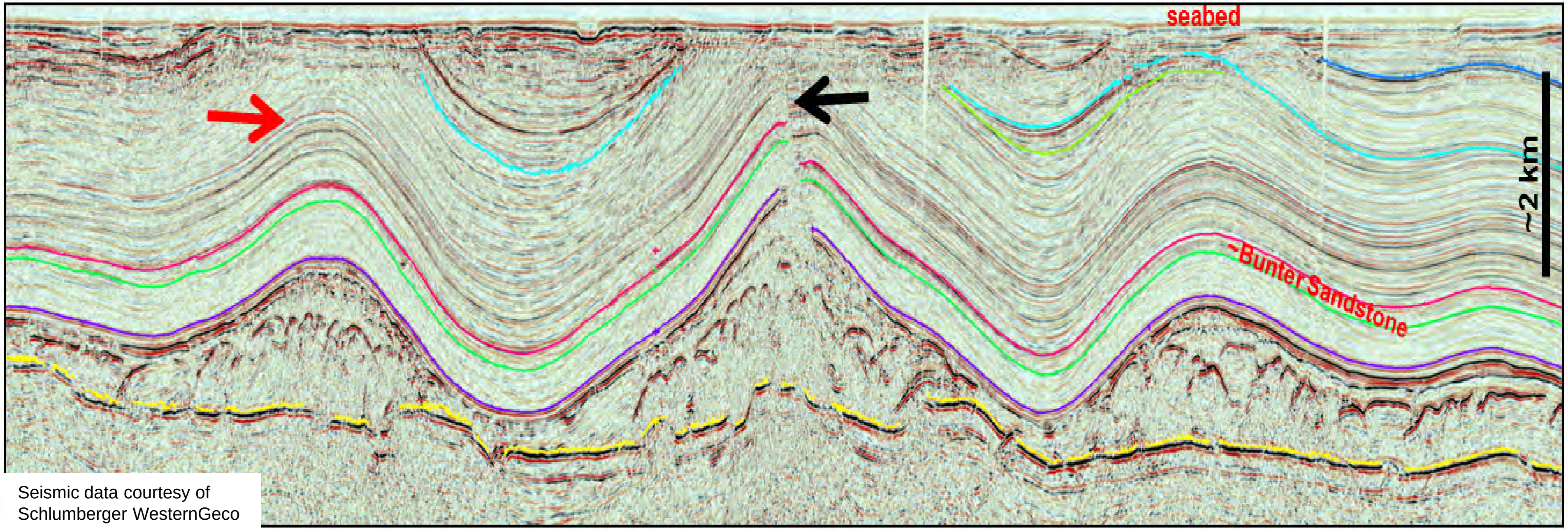
Young rocks – simpler properties

Faults rare in post-rift sequence

Sleipner / Goldeneye

Storage Southern North Sea

Southern North Sea



Seismic data courtesy of
Schlumberger WesternGeco

Older rocks – complex properties

Faults common in syn-rift sequence

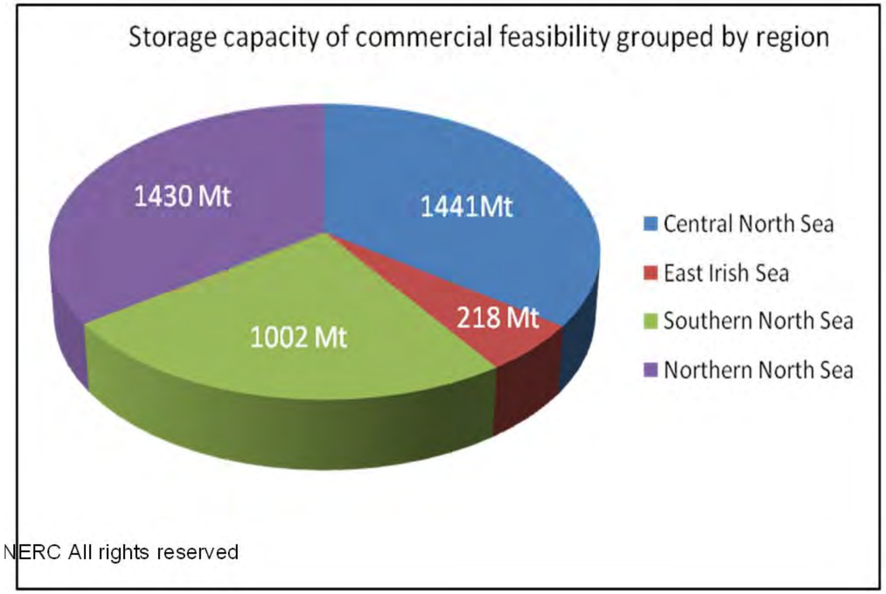
Endurance?

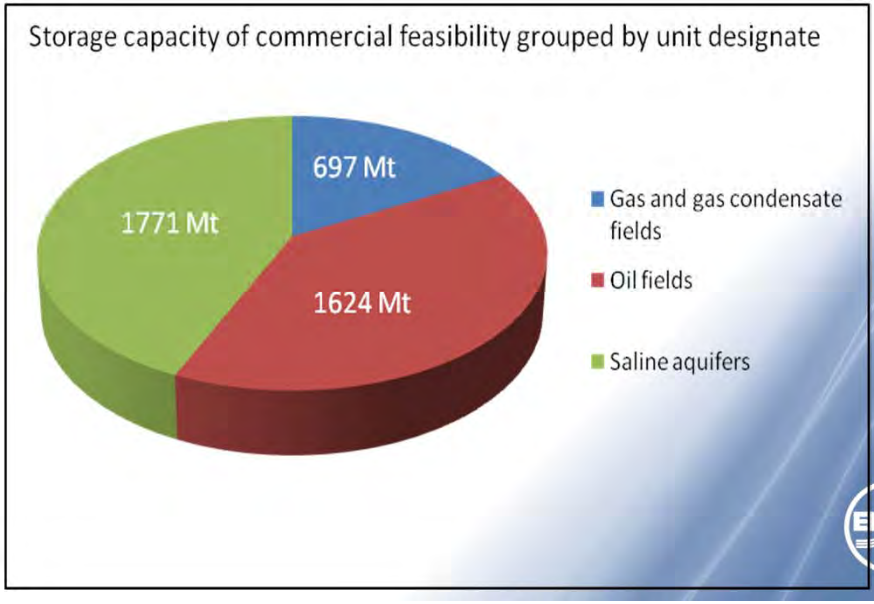
Creating a Portfolio of Storage options for TCE

- 74 (mainly geological) criteria with description and metrics
- 7 categories of criteria were identified
  - Capacity (22 criteria)
  - Containment (24 criteria)
  - Injectivity (17 criteria)
  - Cost (11 criteria)
  - Confidence in the data/results (6 criteria)
  - Conflicts with other users/resources (17 criteria)
  - Licensing (9 criteria)

Results: a ‘flexible’ shortlist

- Basic scores, 35 units with a score of 28 or more
  - 18 CNS
  - 11 NNS
  - 3 SNS
  - 3 EISB
- Commercial feasibility score, 23 units with a score of 24.5 or more
  - 12 CNS
  - 6 NNS
  - 3 SNS
  - 2 EISB

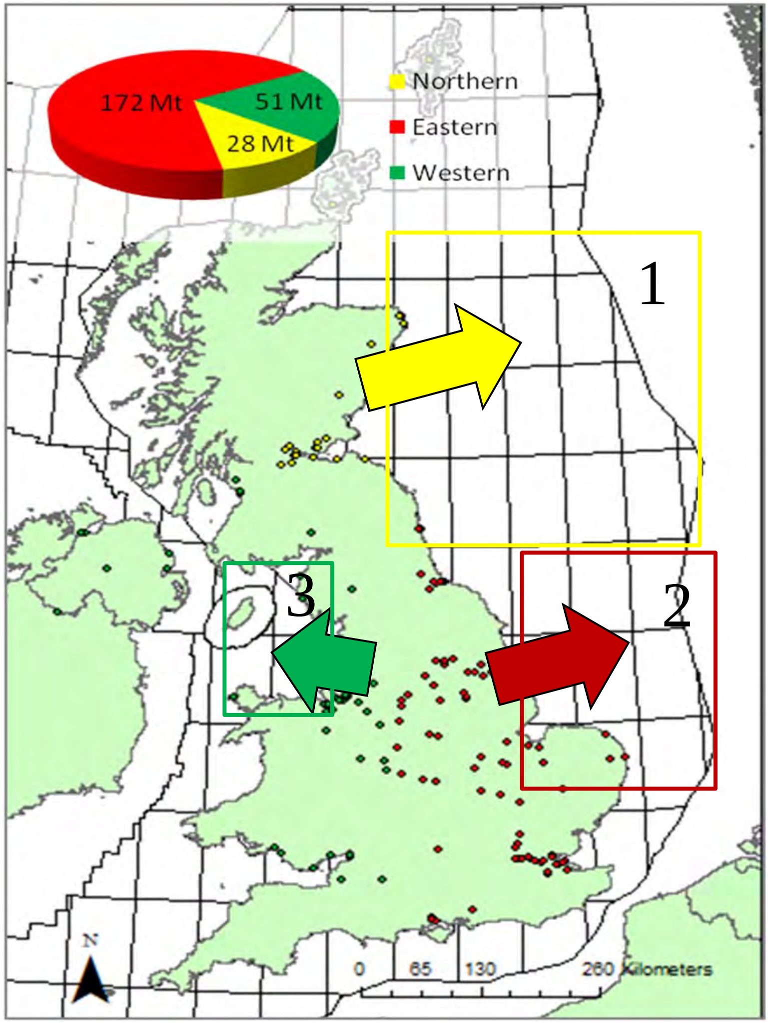




Conclusions from ranking

- Capacity is fairly evenly spread between the SNS, CNS, NNS and EISB
- Natural 'clusters' are forming
- CO_2 Stored is a great screening tool
  - Quickly reached the limits of what CO_2 Stored can be used for
- List of higher ranked storage sites from CO_2 Stored – NOT PROVEN STORES

Scenarios - Regions

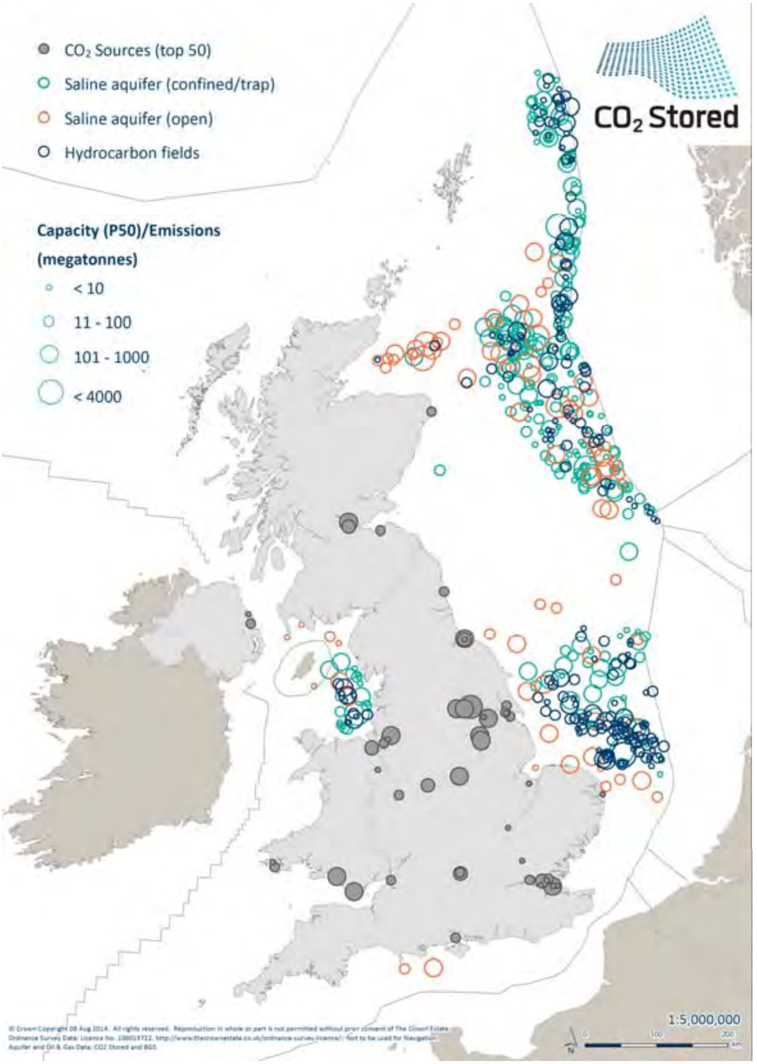


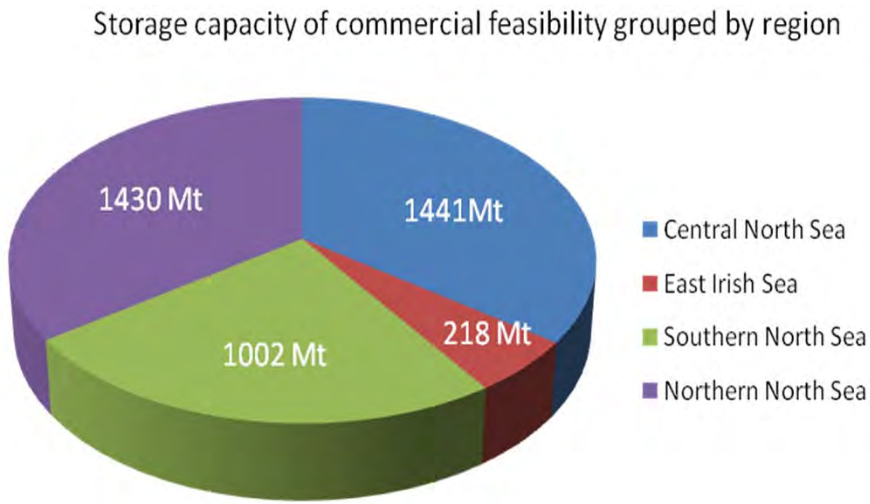
1. Northern emission region supplied CO_2 to CNS and NNS
2. Eastern emissions region supplies CO_2 to the Southern North Sea
3. Western emission region supplies CO_2 to the East Irish Sea Basin

FOCUS: SOUTHERN NORTH SEA

Storage – future focus

Near zero emissions electricity and industry?

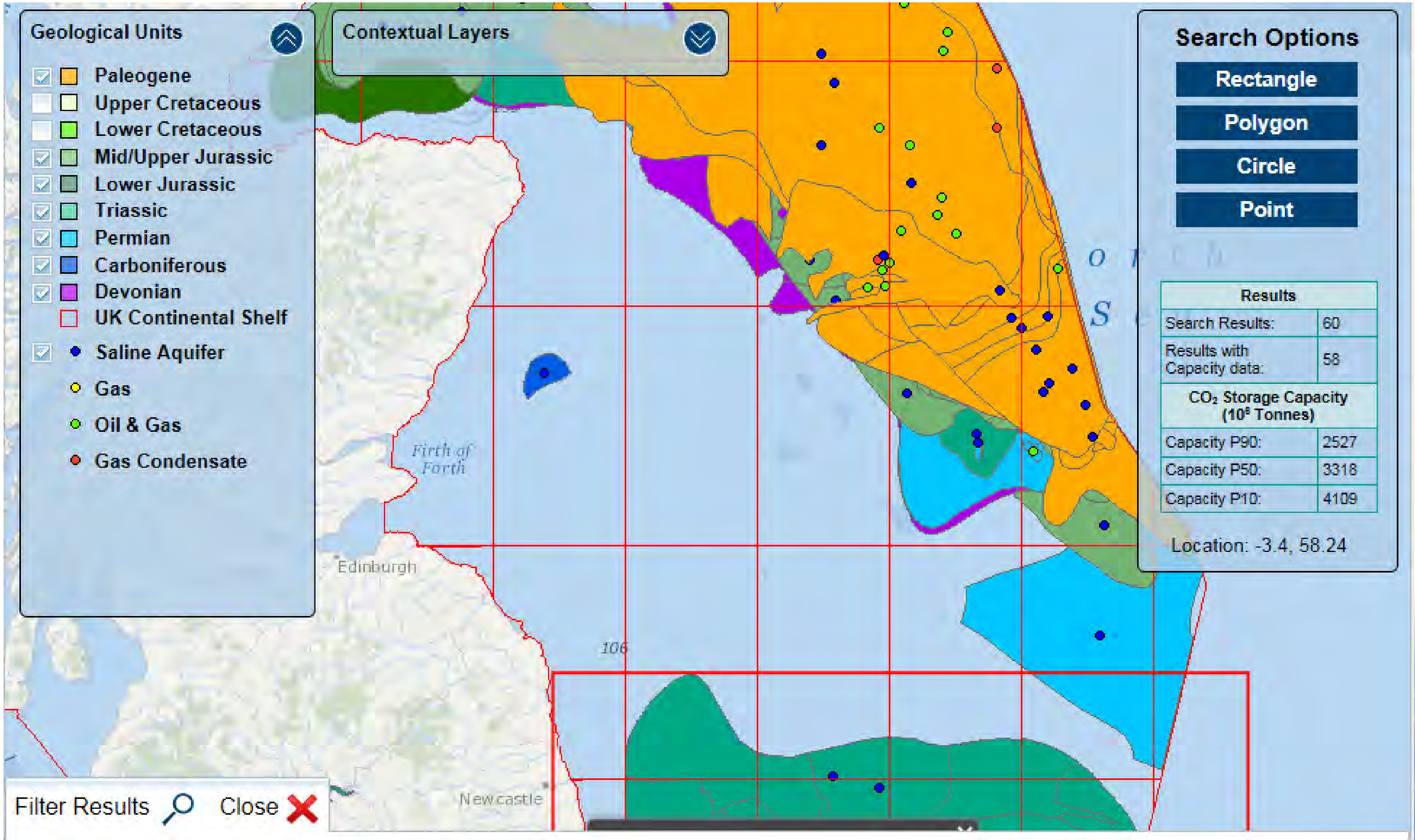




Region	CO_2 emissions Mt in 2008	%	CO_2 Stored per year by 2020 Mt	CO_2 Stored from 2020 - 2030 Mt	CO_2 Stored from 2030 to 2050 Mt
Northern	28	11	1	80	402
Eastern	172	69	1	507	2519
Western	51	20	1	147	730
Total	251	100	3	735	3650

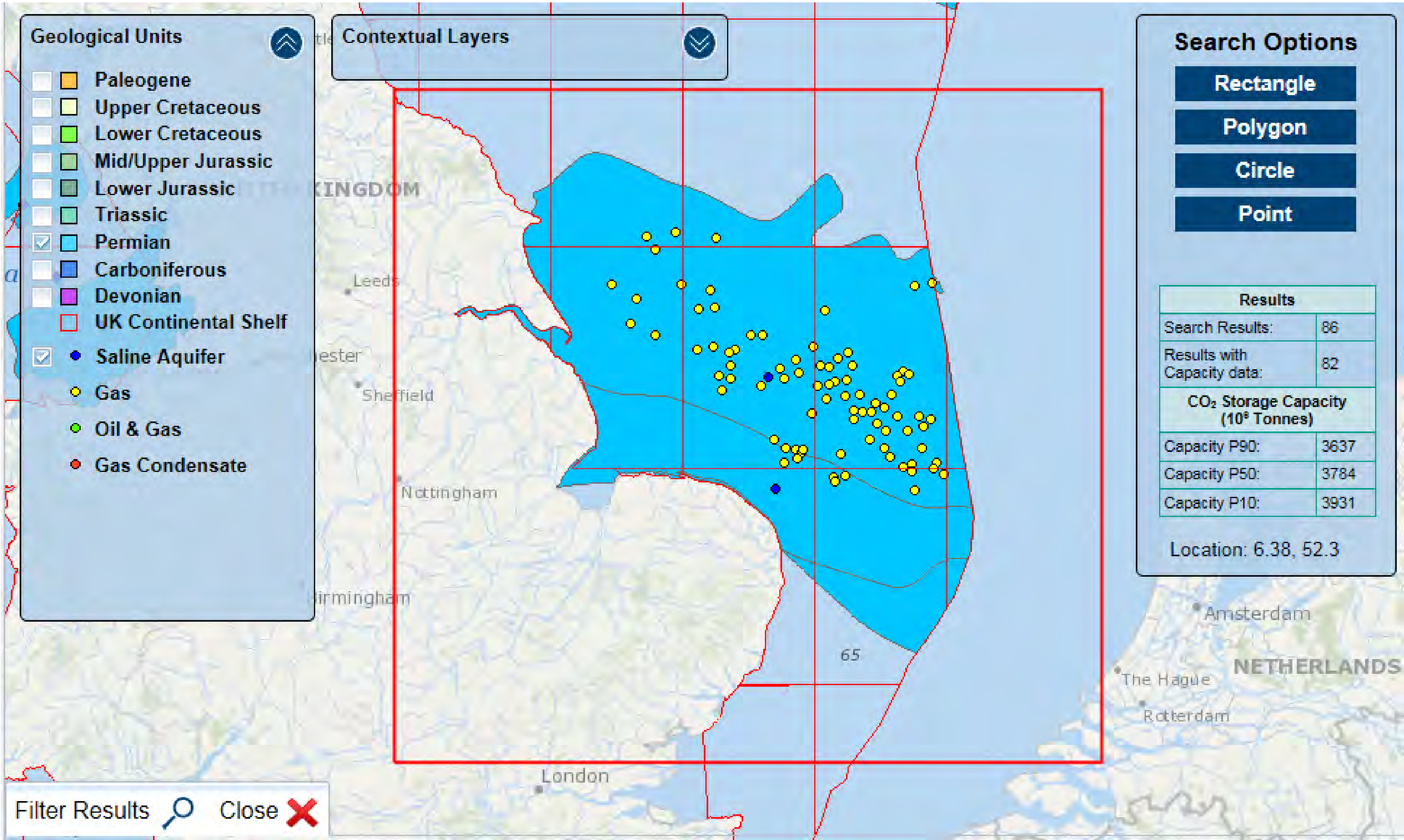
NB// Sources over 100 000t only

Southern Central North Sea



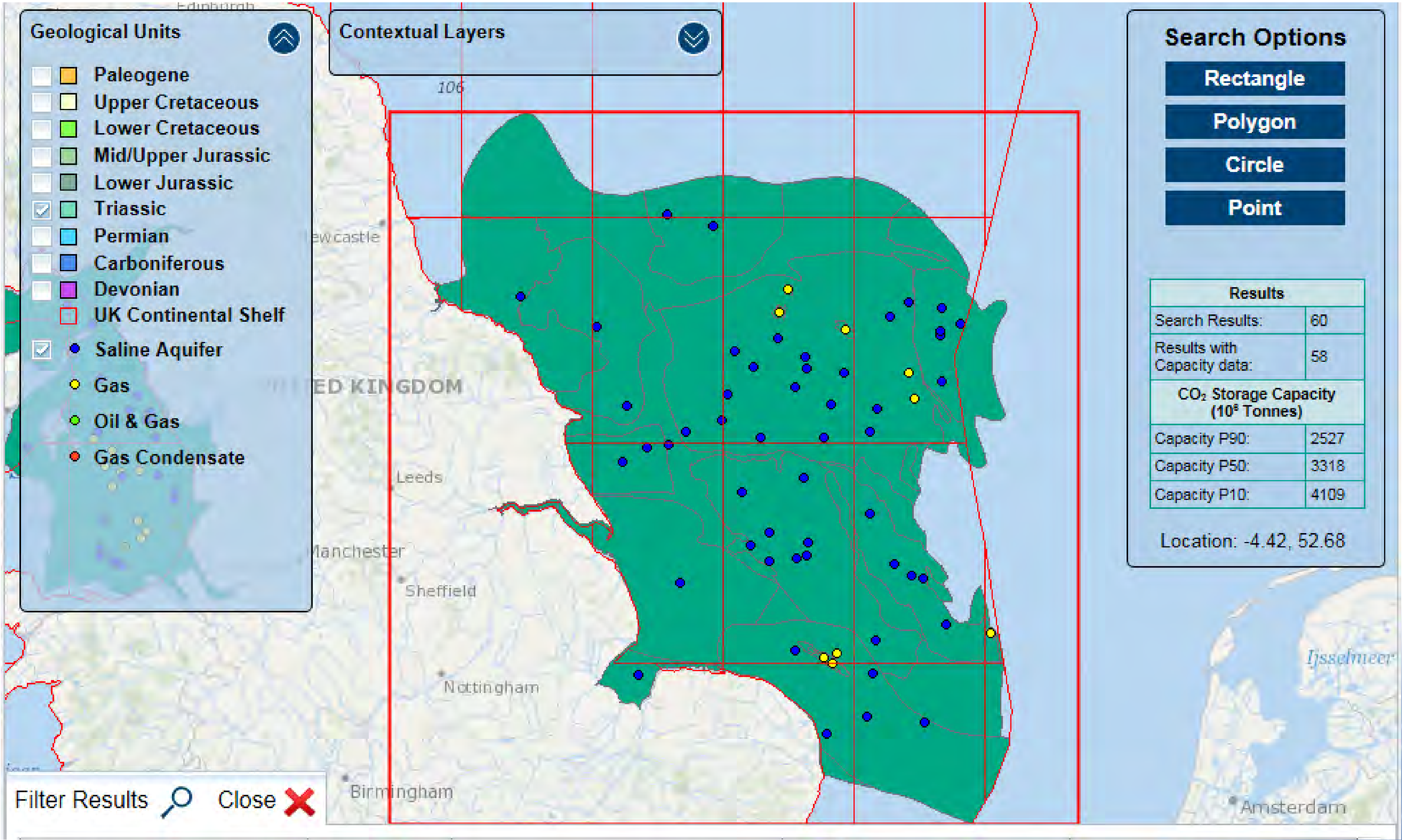
[from CO2Stored database]

Rotliegend gas fields (sub-salt)



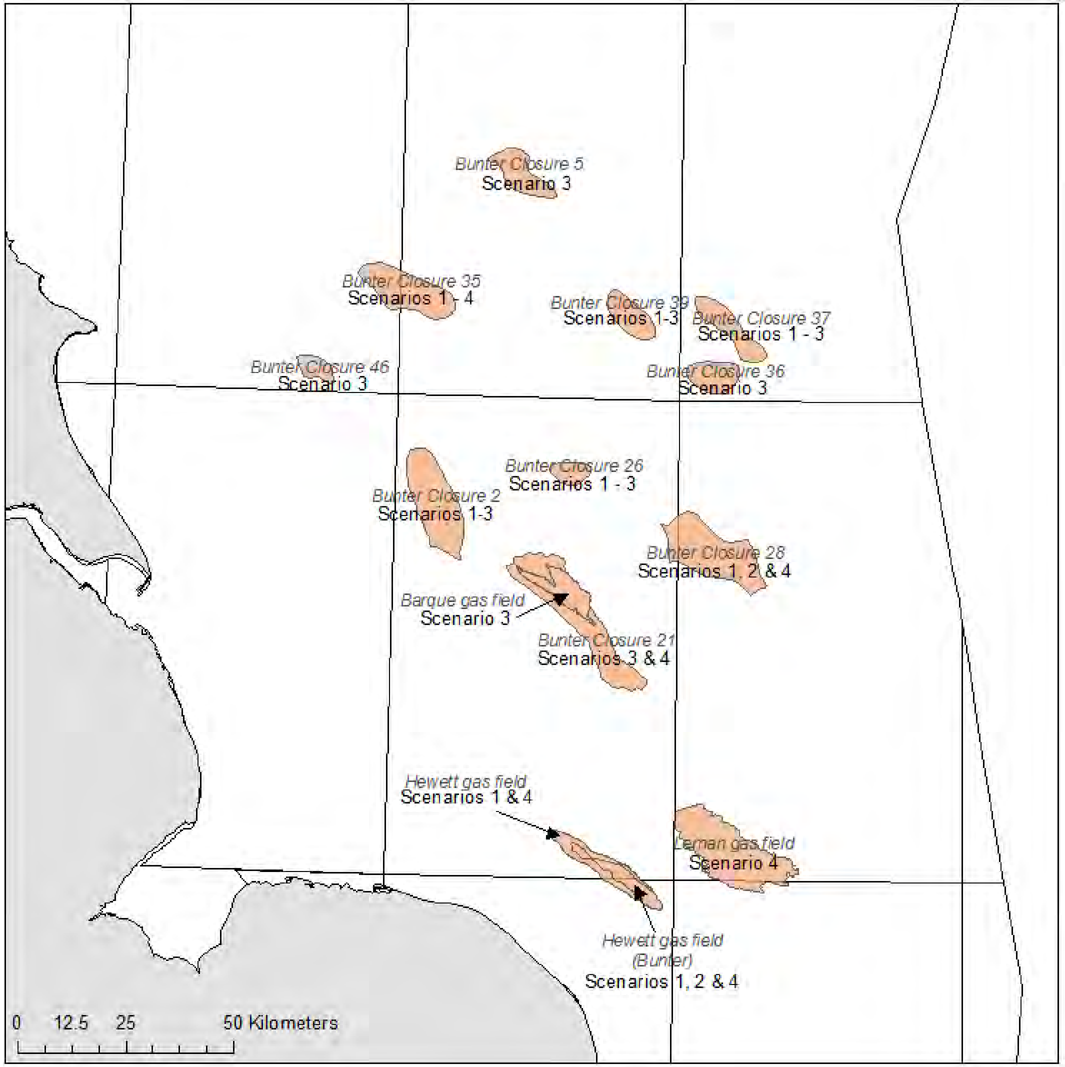
[from CO2Stored database]

Triassic Bunter Sandstone



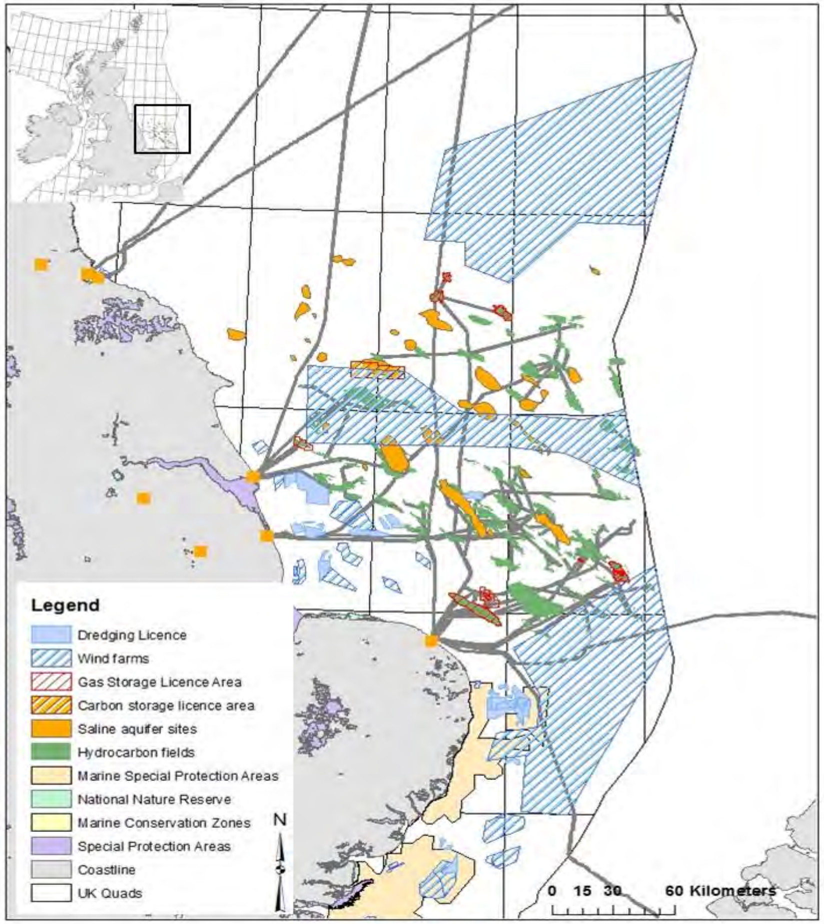
[from CO2Stored database]

Southern North Sea Bunter closures



LEASING ISSUES

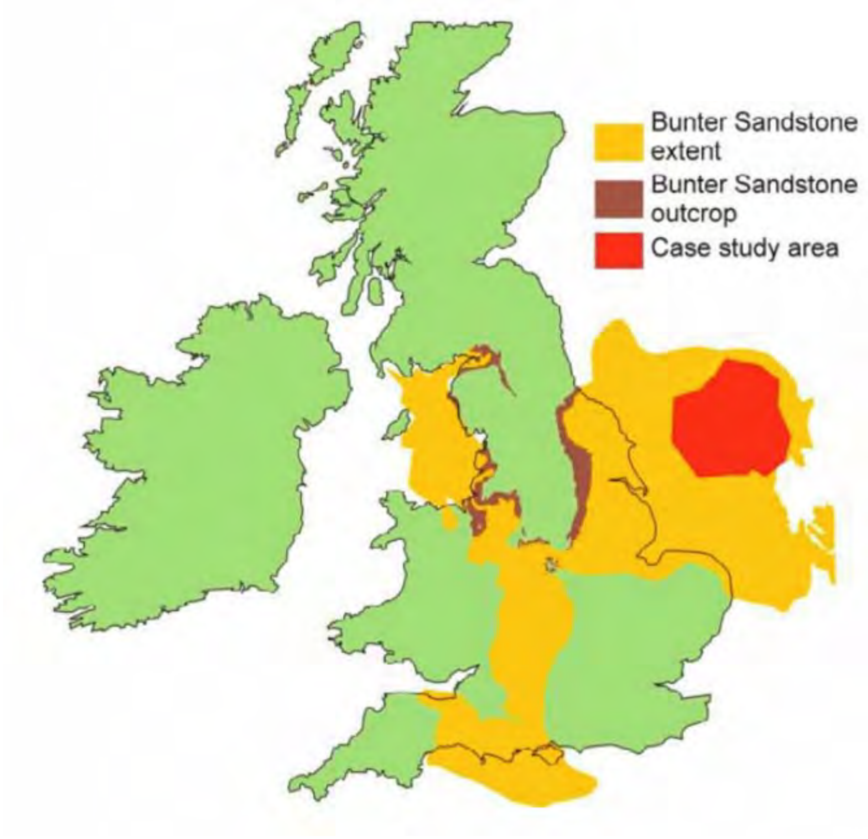
Other users

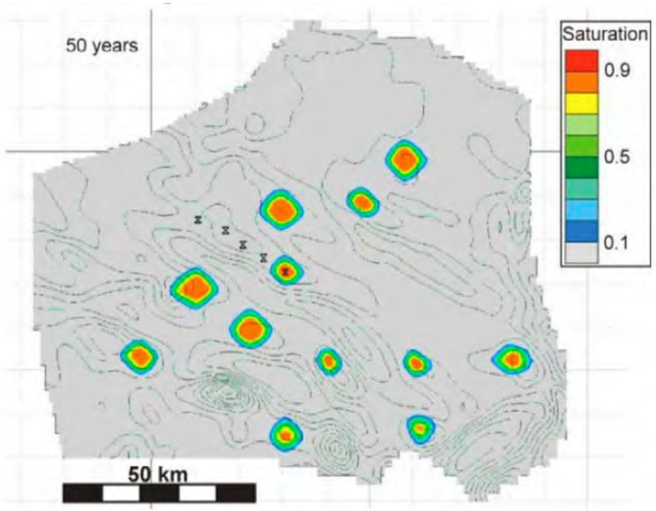

Legend
Dredging Licence
Wind farms
Gas Storage Licence Area
Carbon storage licence area
Saline aquifer sites
Hydrocarbon fields
Marine Special Protection Areas
National Nature Reserve
Marine Conservation Zones
Special Protection Areas
Coastline
UK Quads
N
0 15 30 60 Kilometers

Bunter gas fields of the SNS

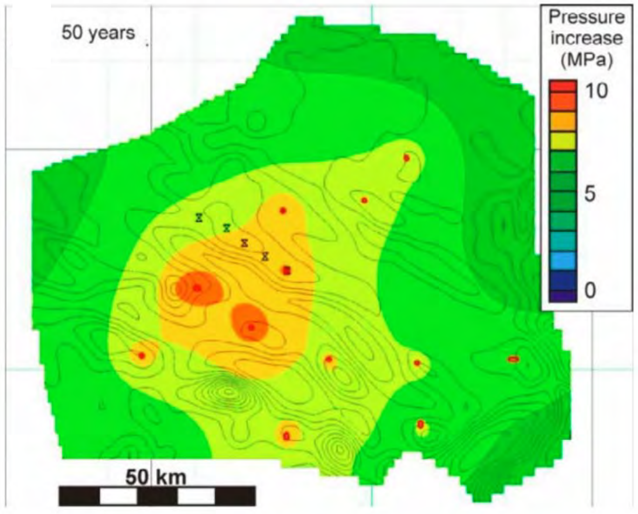
- Gas fields in the Bunter sandstone have been produced by depletion drive
  - Pressure is maintained by connected aquifer waters encroaching into the gas reservoir
- Water drive is indicative of hydraulic and pressure communication within the aquifer:
  - Degree to which water influxes depends on aquifer size and the degree of communication between aquifer and gas reservoir.
  - With strong connection, post-production reservoir pressures will continue to recover.

Leasing issues (lateral interference)





saturation footprint



pressure footprint

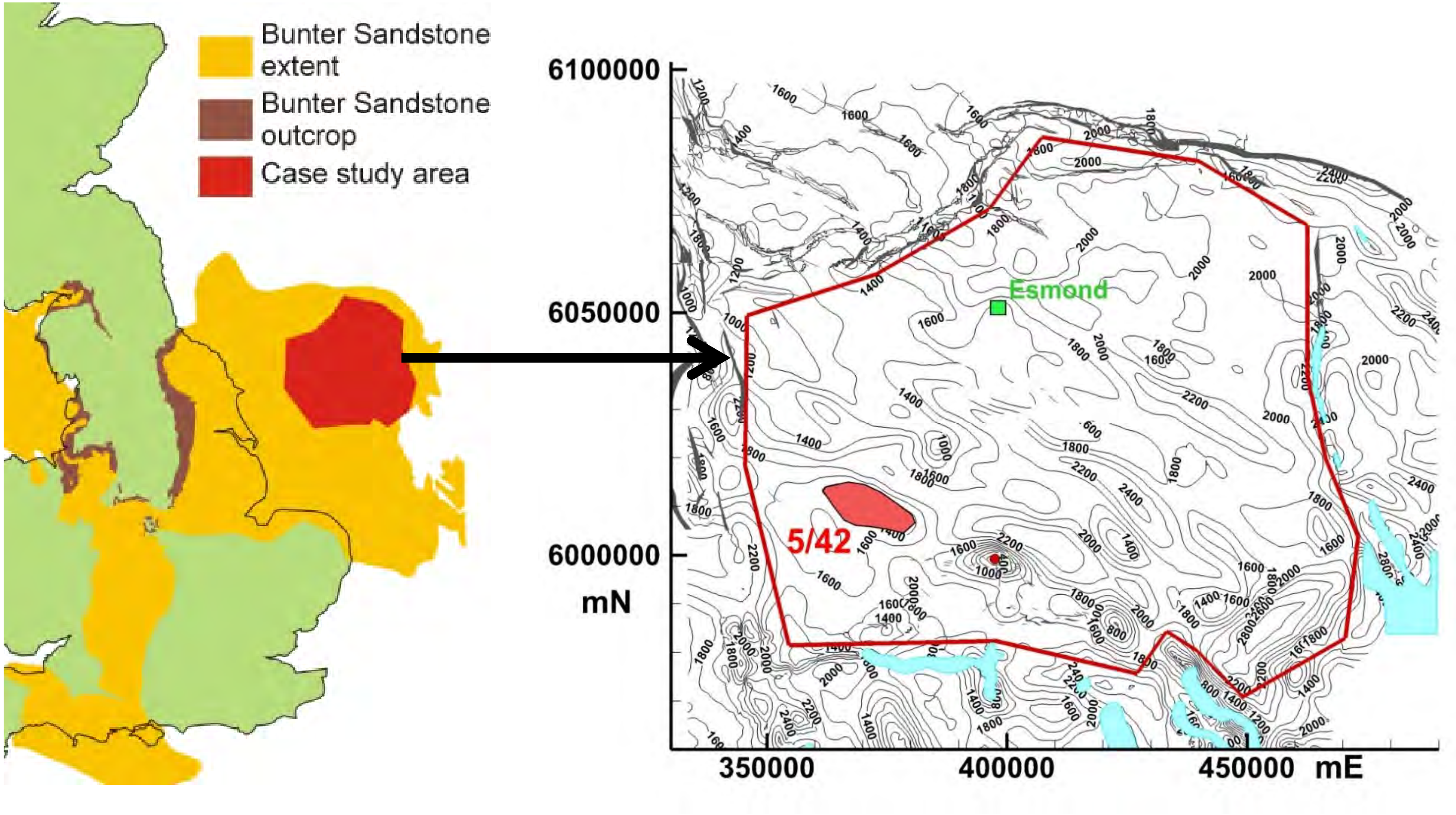
AQUIFER CONNECTIVITY

Rationale

- Funded by The Crown Estate.
- Results reported to DECC and the OGA.
- Key uncertainty in saline aquifers: sustainable injectivity
  - Linked to accessible resource in the local reservoir
- Injectivity testing is costly and increases lead times.
- Testing also pressurises the formation which is counter-productive for storage

- Aim
  - Use natural gas production and subsequent reservoir recharge data to understand the dynamic behaviour of the Bunter aquifer.
  - Use Esmond gas field to place constraints on the possible storage performance at the Endurance structure (5/42).

Esmond analogue



NEXT STEPS

Need to provide guaranteed storage

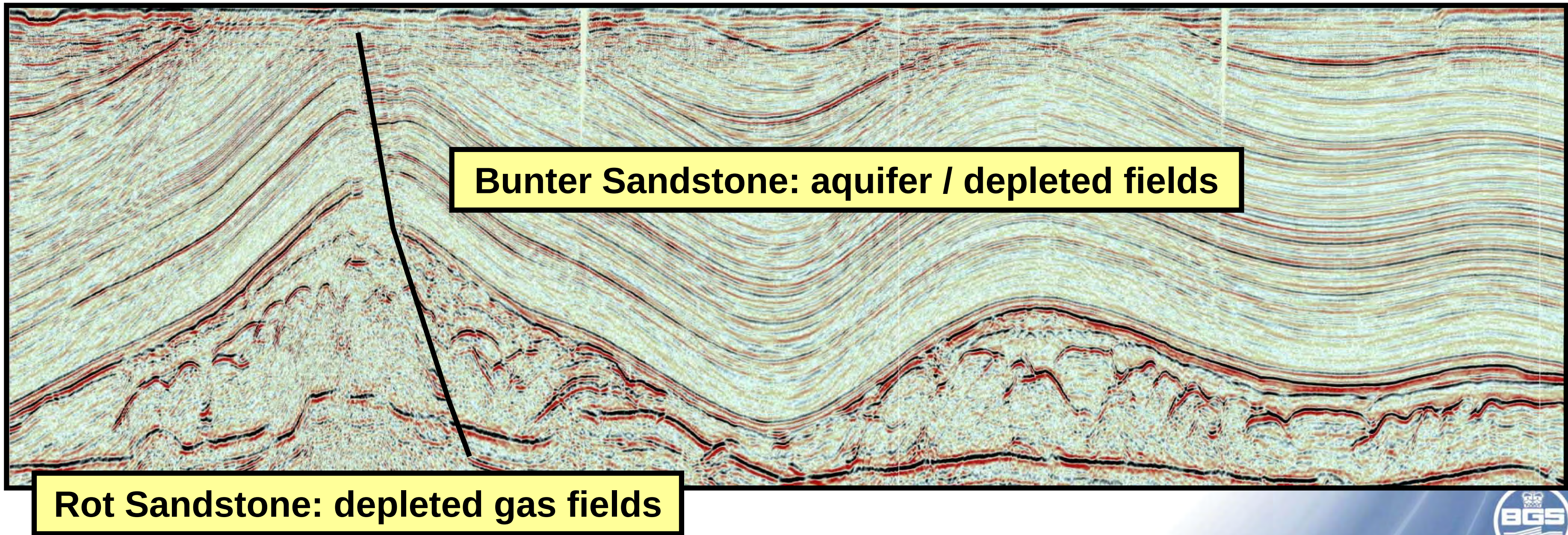
- **Primary storage target plus multiple back-up options**
- ***Primary Storage target***:
  - Bunter Sandstone reservoirs beneath the Southern North Sea
- Static properties
  - Porosity and permeability uncertainties due to the variable diagenesis (cementation) in the reservoir.
  - Seismic attributes
  - Well logs
- Dynamic properties
  - In situ pressure in depleted fields
  - Dynamic well testing (White Rose test well / new test wells)
  - Dynamic modelling
- Topseal integrity
  - Fault properties
  - Effective stress

Need to provide guaranteed storage

- **Primary storage target plus multiple back-up options**
- ***Primary Storage target***:
  - Bunter Sandstone reservoirs beneath the Southern North Sea
- The White Rose project has drilled a test well into the aquifer and has carried out a range of dynamic tests. The extent to which these prove suitability for large-scale storage (>100 Mt) is uncertain however. A targeted long-term research programme could reduce these either by re-utilising the National Grid well or drilling an additional test well.

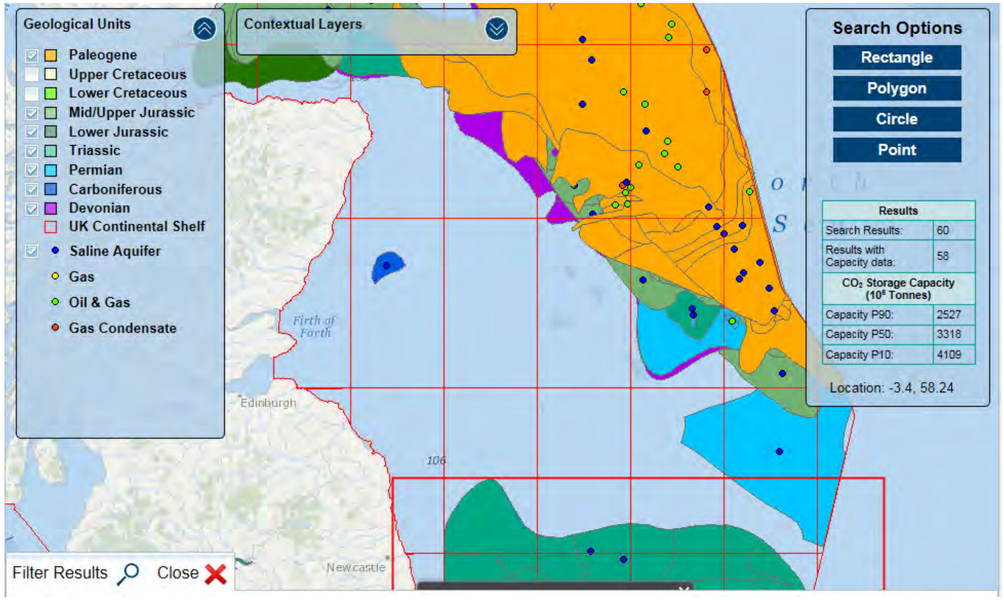
Back-up Storage options

- ***First backup target:***
- Rot Sandstone depleted gas fields in Southern North Sea.
  - Beneath the thick Rot Halite salt
  - Not particularly well imaged on seismic.
  - Small fields
- Strongly pressure compartmentalised
- Effective storage utilisation will require careful characterisation and planning.
- Optimal compartment combinations



Back-up Storage options

- ***Second backup target:*** Depleted hydrocarbon fields in Central North Sea (CNS)
  - Optimal sites.
  - Re-usability of infrastructure.
  - Other users.
  - [Longer pipeline required to store in CNS, but this might be able to tap into industrial CO_2 emissions from Teesside].



[from CO2Stored database]

Conclusions

- Lots of theoretical capacity and potential storage sites
- We know how to characterise sites
- Desk studies on five sites by DECC (ETI) and others e.g. BGS, SCCS Multistore etc

- Strategic integrated transport & storage needed to guarantee storage availability
    - Multiple stores in (integrated) clusters

THANKS