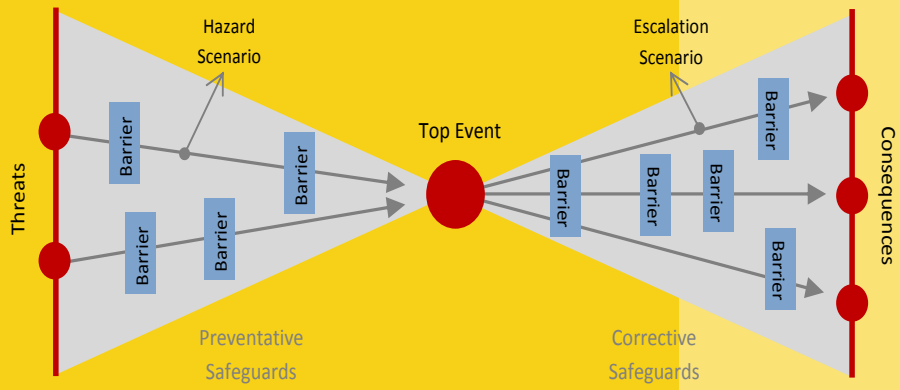
RISK MANAGEMENT AND MONITORING STRATEGY OFFSHORE

Peterhead CCS Project

August 2015



Dr Owain Tucker
Global Deployment Lead CCS

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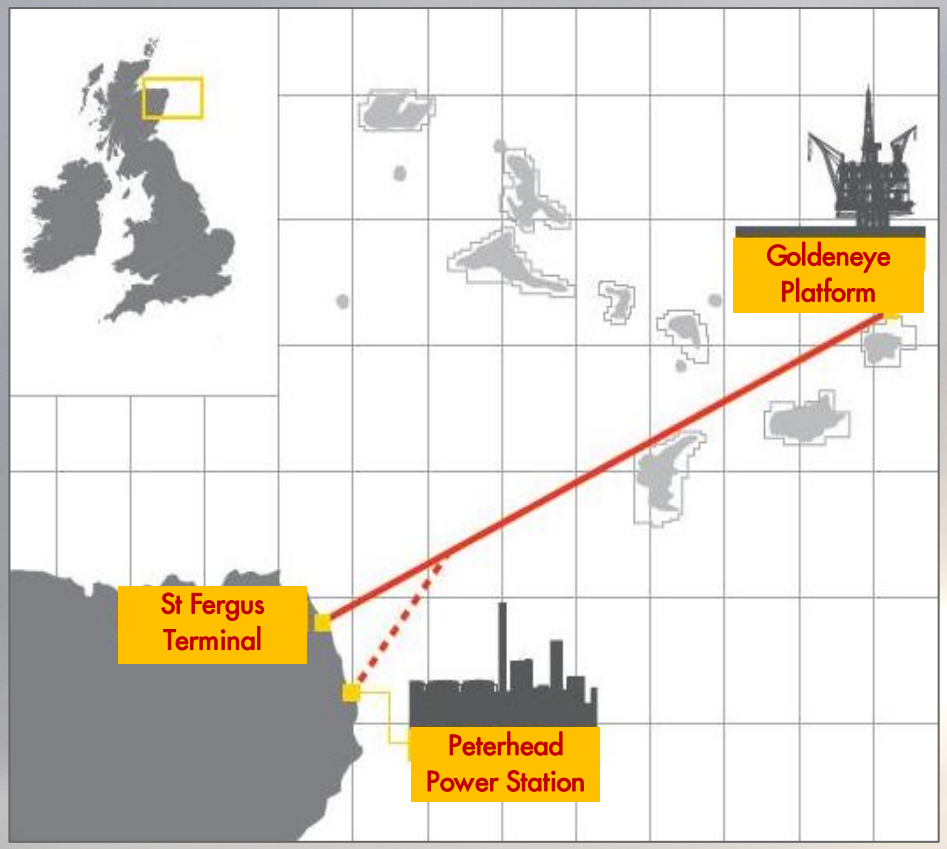
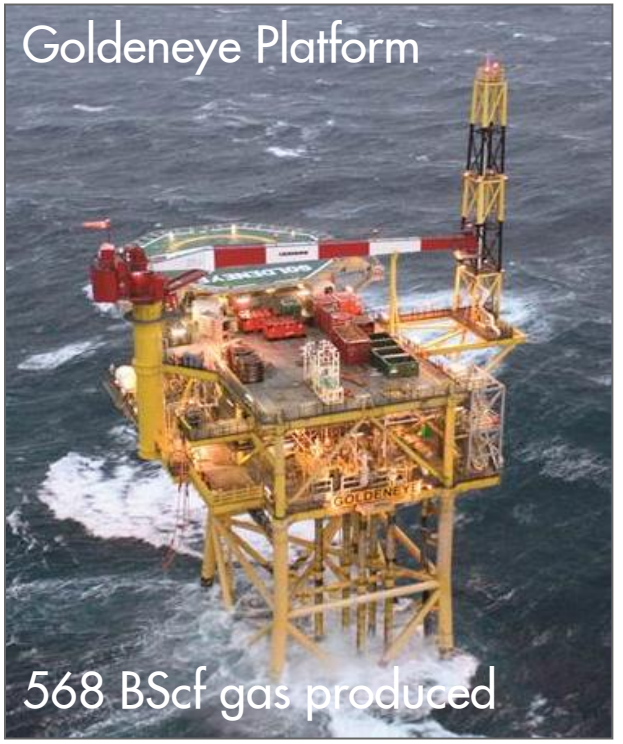
PETERHEAD CCS PROJECT OVERVIEW

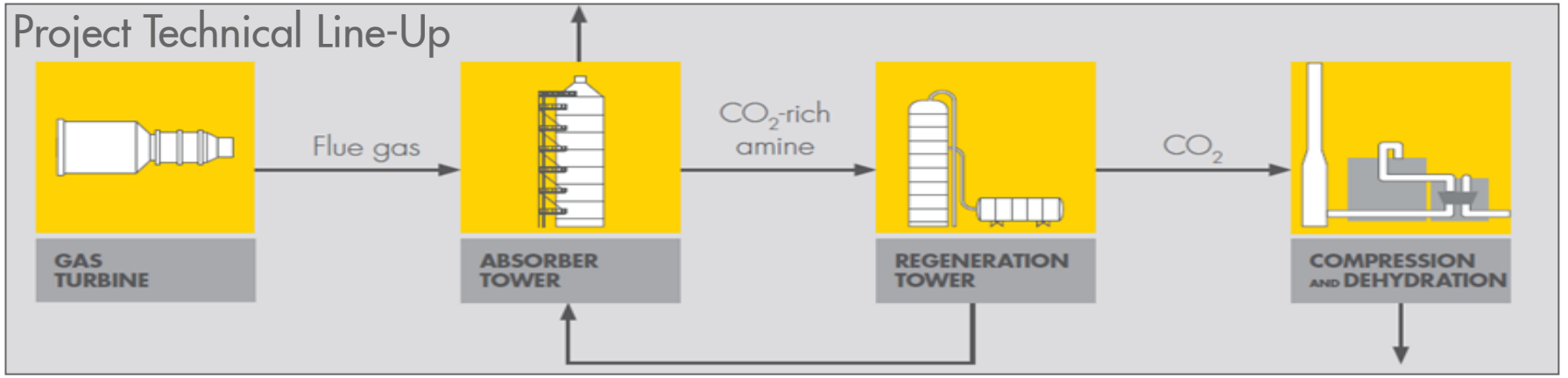
PROPOSED PETERHEAD PROJECT AT A GLANCE

- **World First** – the first full-scale CCS project on a gas-fired power station
- **Status** – proposal currently in Front End Engineering Design phase, seeking regulatory approvals and Government funding for capital and operating expenses
- **Where** – capture at Peterhead Power Station; storage in depleted Goldeneye gas reservoir (100 KM offshore)
- **Impact** –10 to15 million tonnes of CO_2 captured over a 10 to 15-year period (90% CO_2 capture from one turbine)
- **Technology** – post-combustion capture using amines



RETROFIT AND REUSE





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OFFSHORE RISK MANAGEMENT & MONITORING

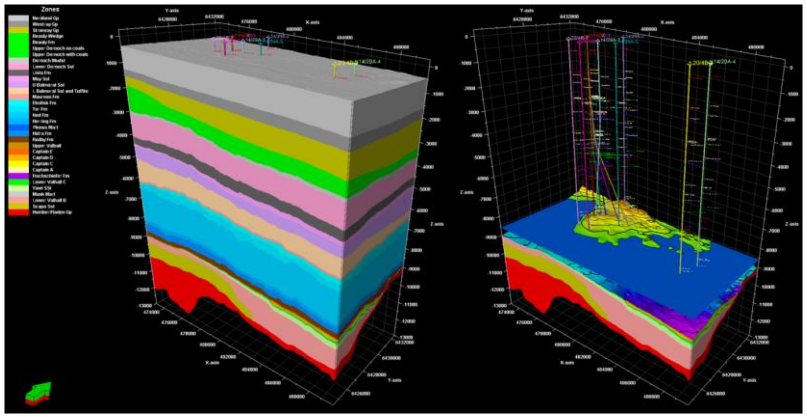
MMV PLAN OBJECTIVES

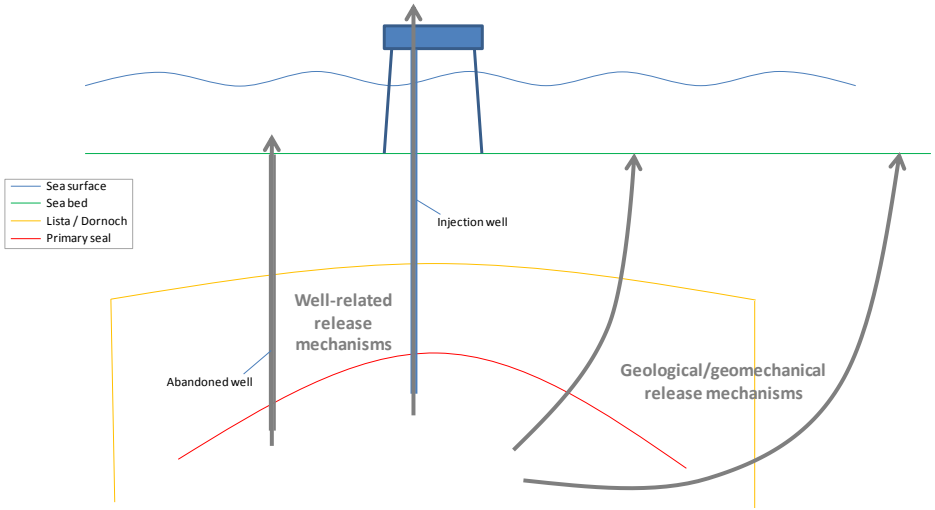
- **Ensure Conformance** *to indicate long-term effectiveness of CO_2 storage*
  - demonstrating actual storage performance is consistent with expectations about injectivity, capacity and CO_2 behavior inside the storage complex

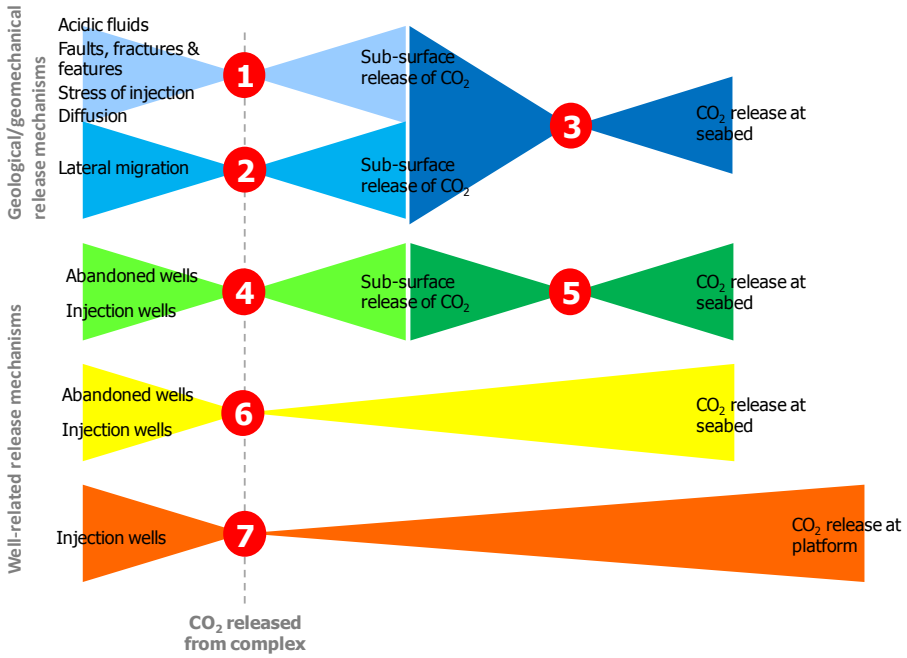
- **Ensure Containment** *to demonstrate the safety of CO_2 storage*
  - detect significant irregularities, migration and leakage of CO_2
  - detect significant adverse effects to environment and human health

- **Verify Safeguards**
  - Verifying the expected effectiveness of existing safeguards created by site selection, site characterization and engineering designs
  - Creating additional safeguards using monitoring systems to provide early warning to trigger timely corrective measures

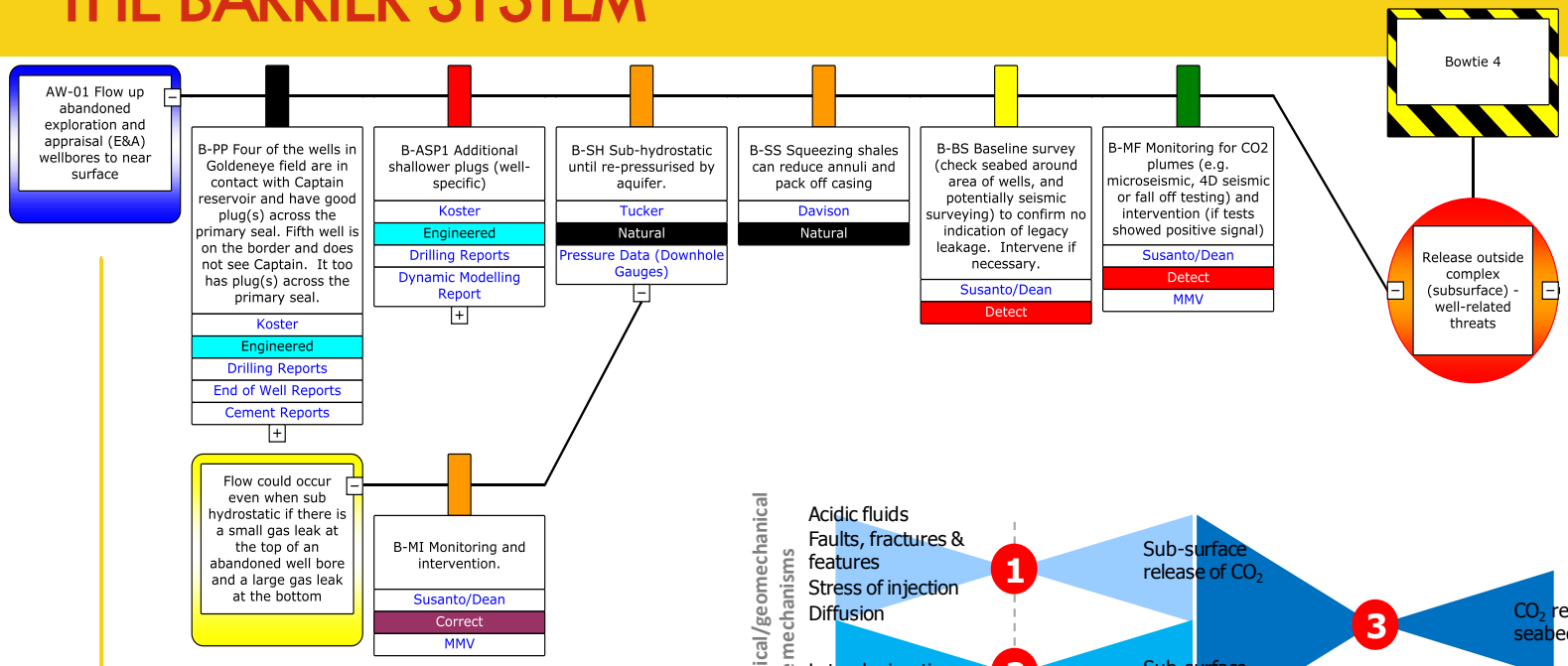
SET OF LINKED BOW-TIES CREATED

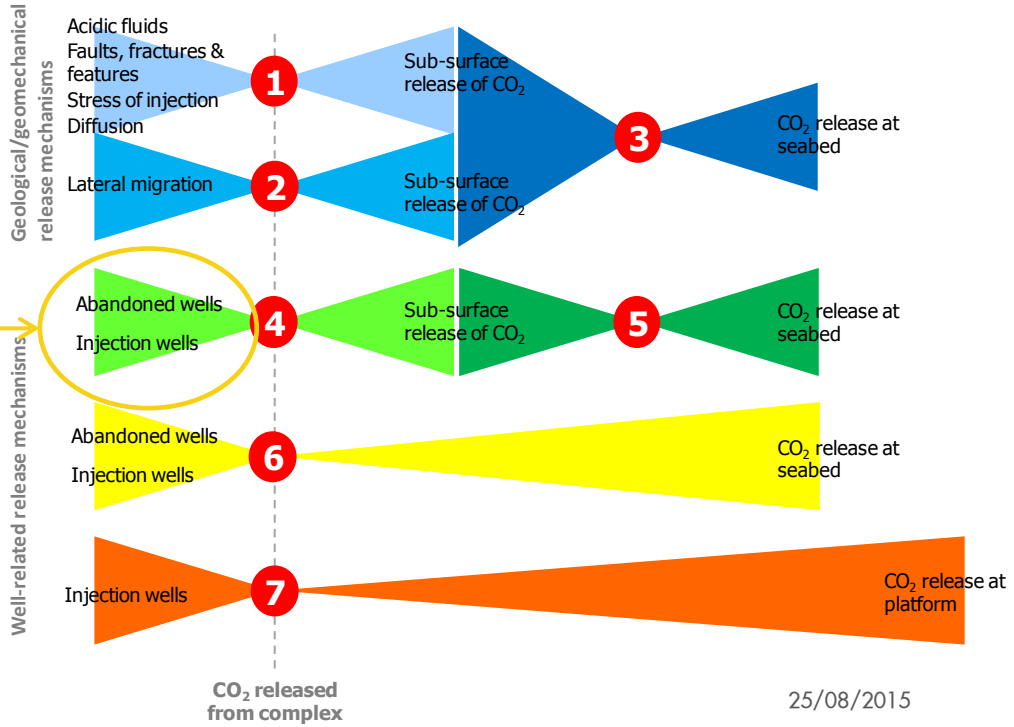






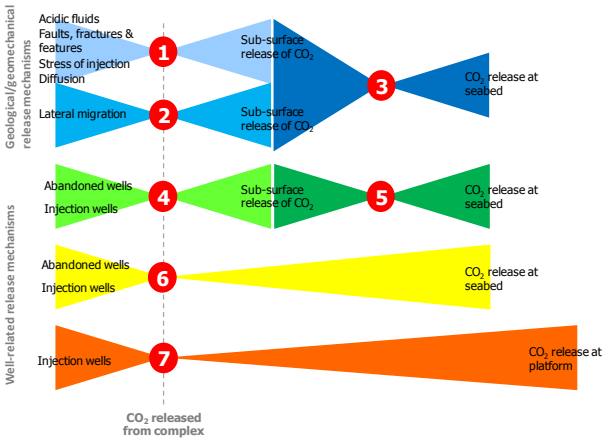
MONITORING AND CORRECTIVE MEASURES FORM PART OF THE BARRIER SYSTEM

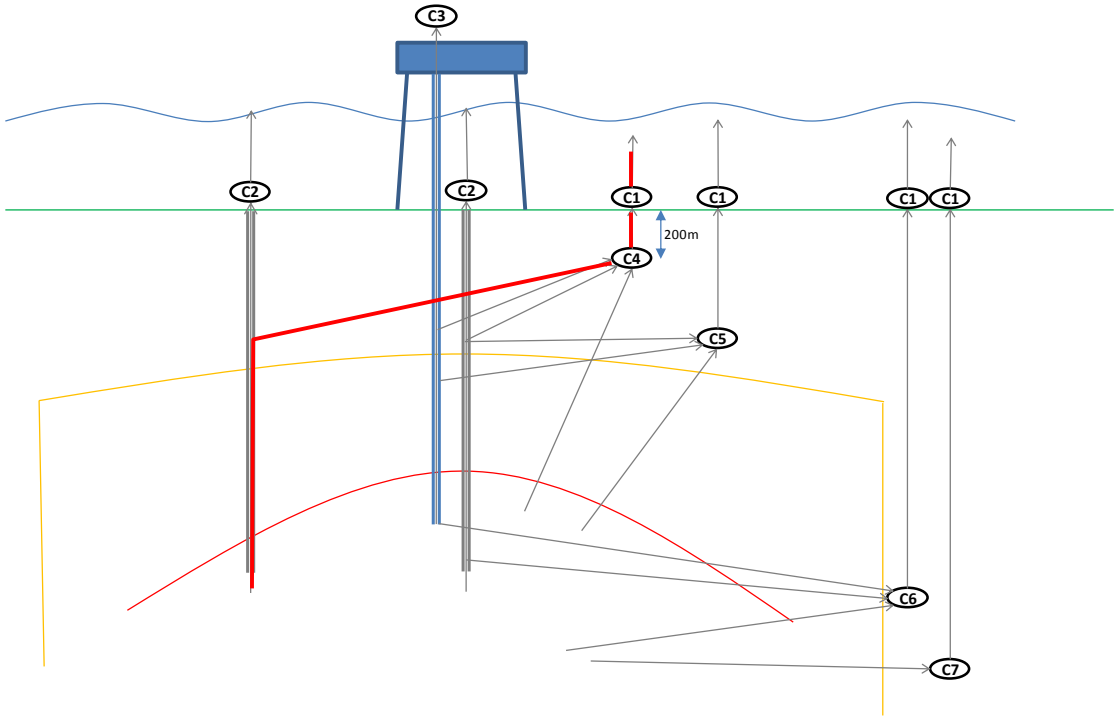




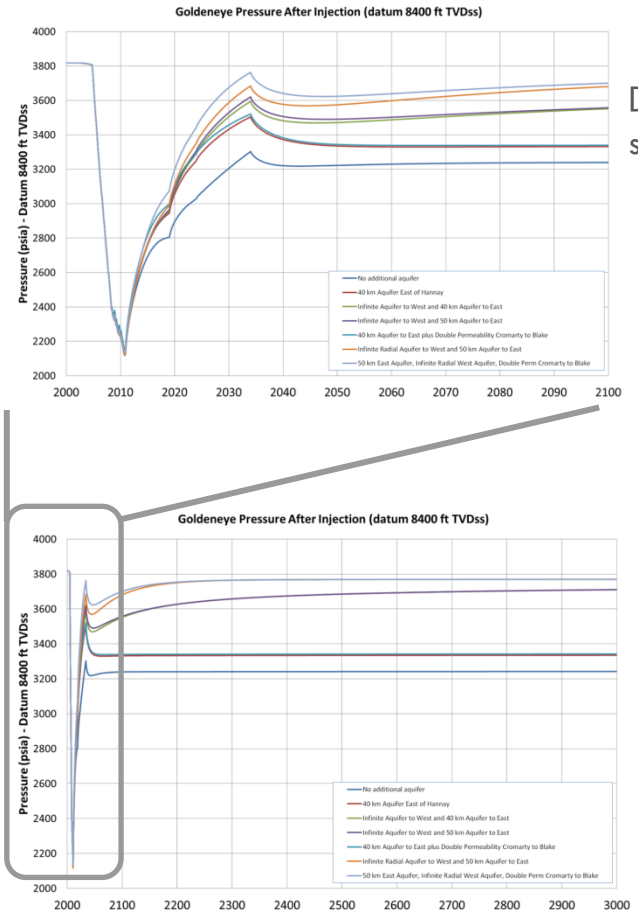
NOT ALL THREAT BRANCHES HAVE THE SAME IMPACT ON RECEPTORS

- Well related pathways have the ability to rapidly bring CO_2 to the surface or near surface
- All other paths involve significant buffering/delaying steps

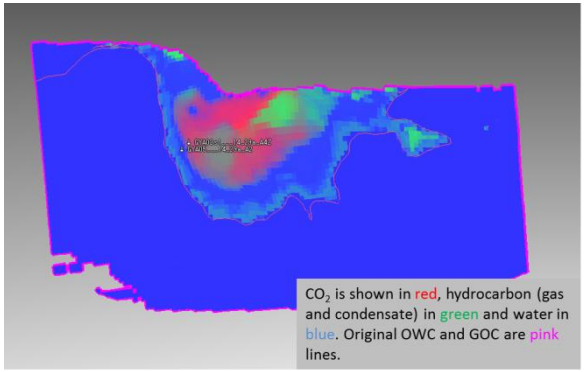


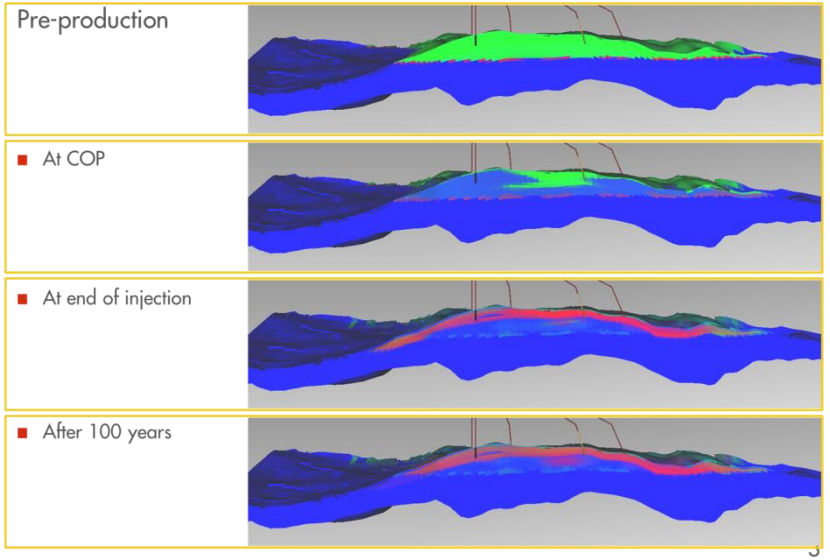


PRESSURE IS REDUCED BECAUSE OF PRODUCTION, CO2 IS LOCALISED IN THE HYDROCARBON FIELD LOCATION



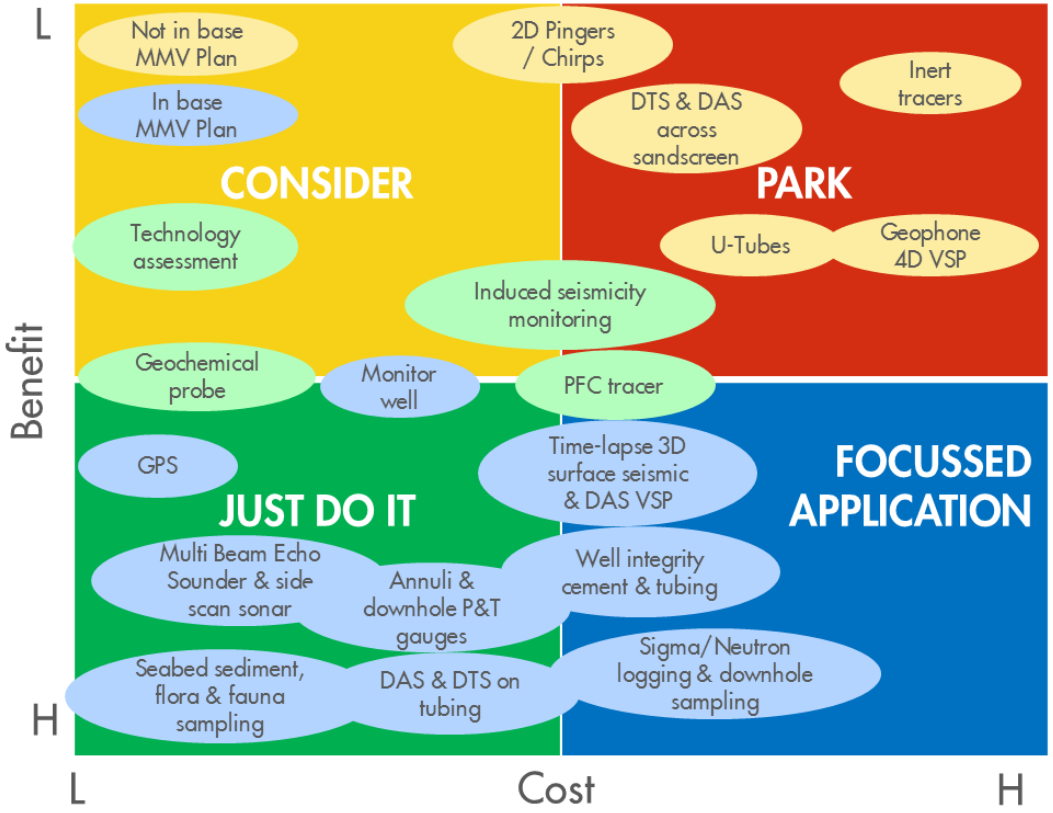
Different aquifer scenarios

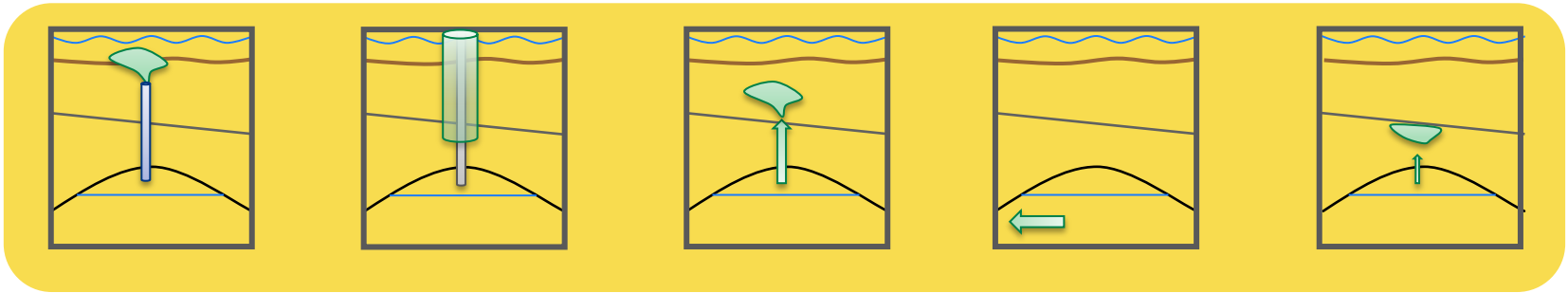




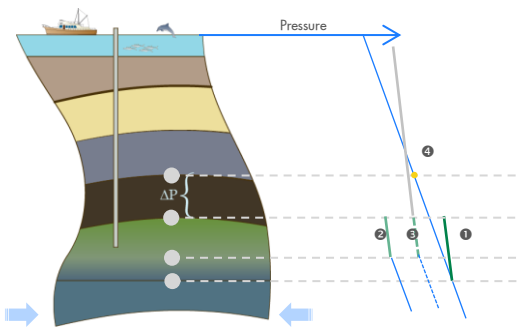
SELECTING THE BEST MONITORING TOOLS

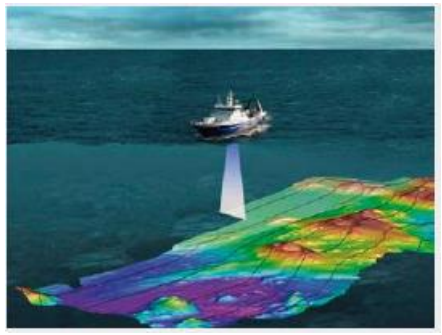
- Test each potential technology against valid migration scenarios for each phase of the project.
- Select a set based on tiered monitoring strategy: detect, define, delineate

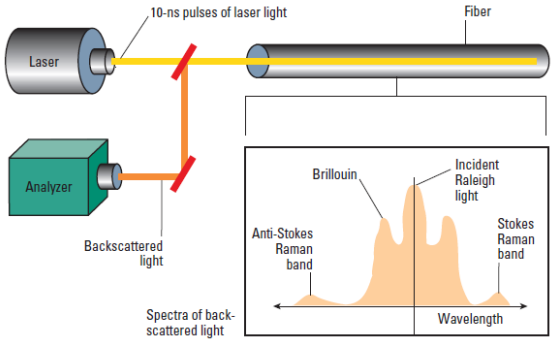




FIT FOR PURPOSE MONITORING PLAN







Base monitoring detect, conformance

Start | End

Pre-inj	Injection	Post-closure	Post hand over
Baseline	Continuous: well integrity, sea-bed, well by well flow metering, CO_2 quality, reservoir P, DAS, DTS	MBES (+1 y, +6 y)	Multi beam echo sounder x 2
4D seismic (complex) + VSP	Mid: Tracers; 4D [3D VSP]	4D seismic, store; Reservoir P, 1.5 years	

Irregularity/contingency monitoring if irregularity suspected

- Established a set of monitoring technologies that
  - satisfy the conformance requirement
  - add extra barriers or controls to the existing barriers to reduce the risk of a significant irregularity even further