Carbon Capture Utilisation & Storage

Reservoir Engineering Perspectives

Gaffney
Cline

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Who are we?

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Global Presence

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Expertise Across the Energy Value Chain

Upstream

Geology
Geophysics
Petrophysics
Reservoir Engineering
Drilling and Completion
Facilities
Production

Midstream & Downstream

Gas & LNG
Pipelines
Process
Operations
Refining
Chemicals
Power
Marketing

Energy Transition

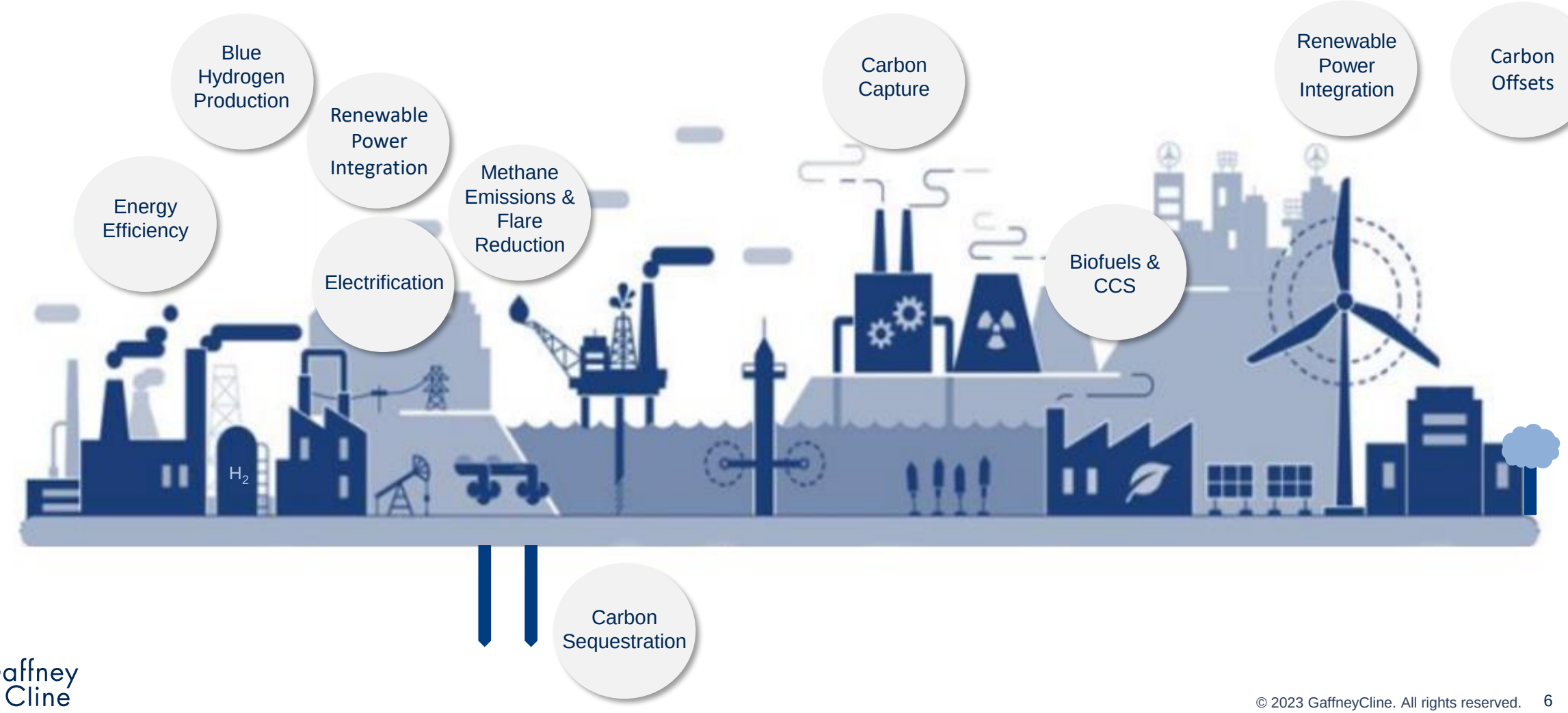
Quantifying Emissions
Abatement Solutions & Strategies
Financial Incentives & Support
Market, Policy & Regulation

Functions

Economics
Commercial & Financial
Legal, Regulatory & Fiscal
Strategy & Planning
Organisation
Business Processes
Carbon Management

CCS is an Essential Climate Technology to Reach Net Zero

GaffneyCline has the capability and experience to support decarbonisation of energy production and consumption



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CCUS

Overview

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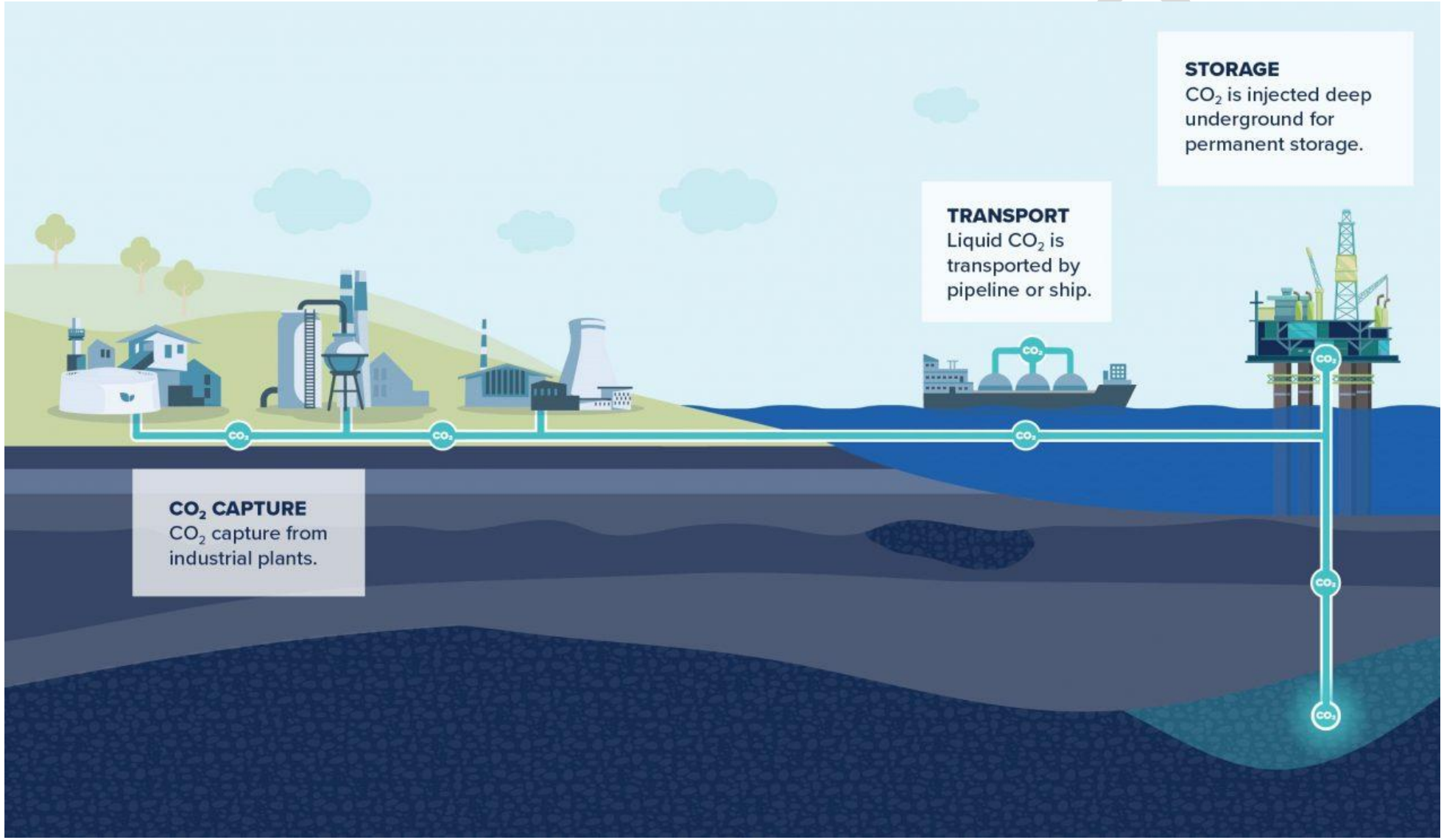
Carbon Capture and Storage (CCS)

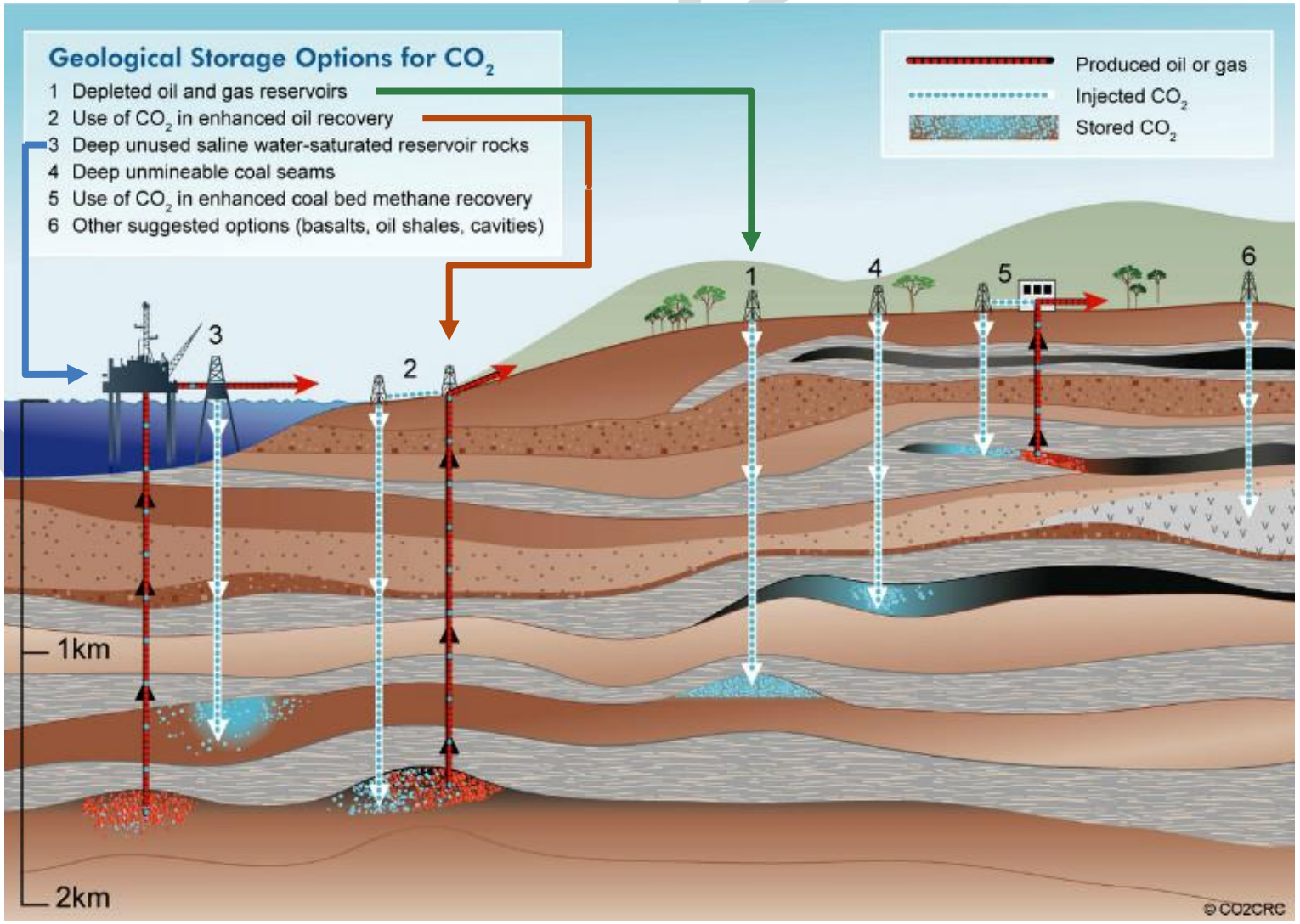


Source: GCCSI

Geological CO_2 Storage

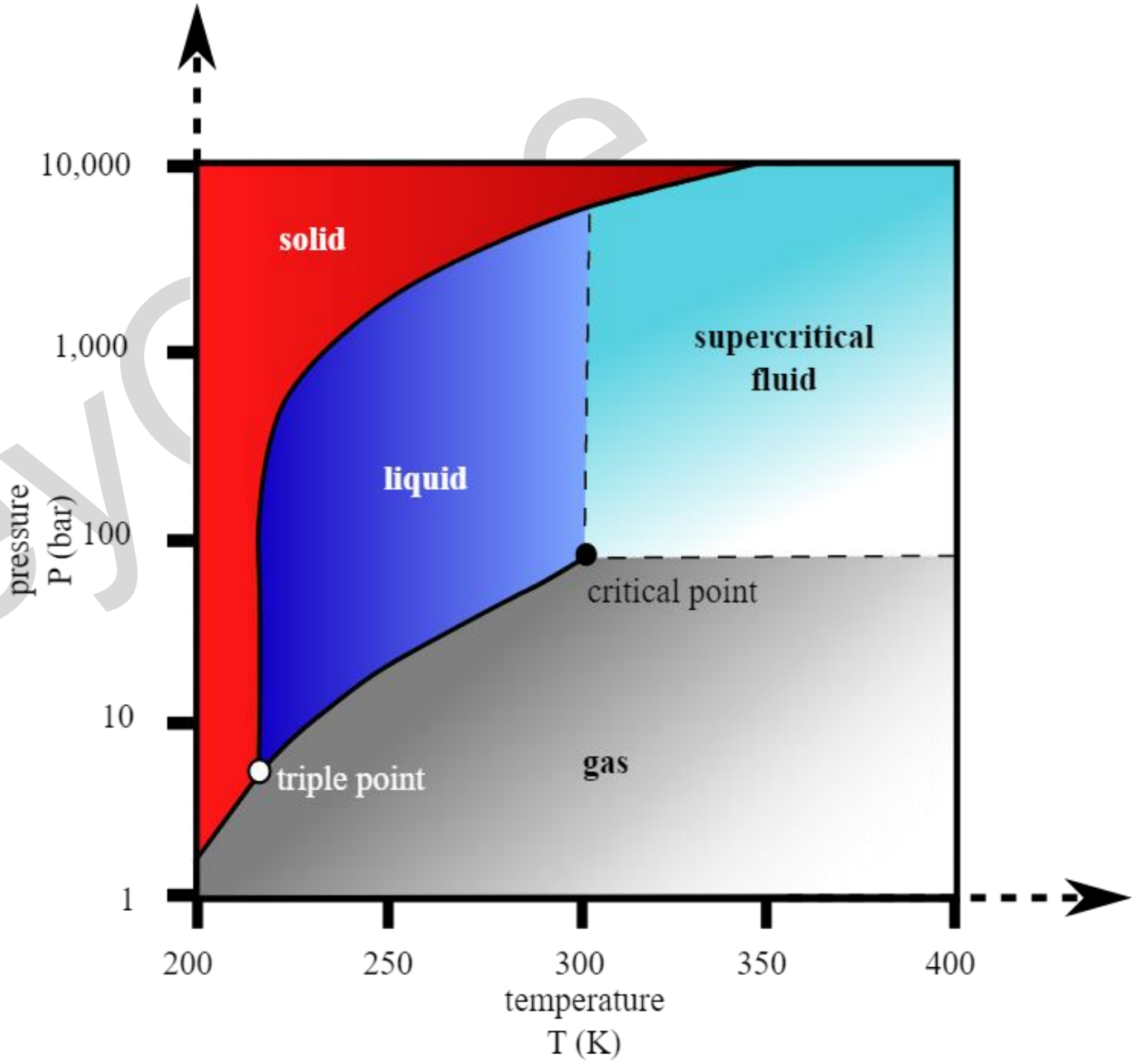
- Main options
  - Deep saline aquifers
  - Depleted oil/gas reservoirs

- Differences in:
  - Storage mechanisms
  - Operational challenges
  - Data availability
  - Infrastructure
  - Timing
  - Risk



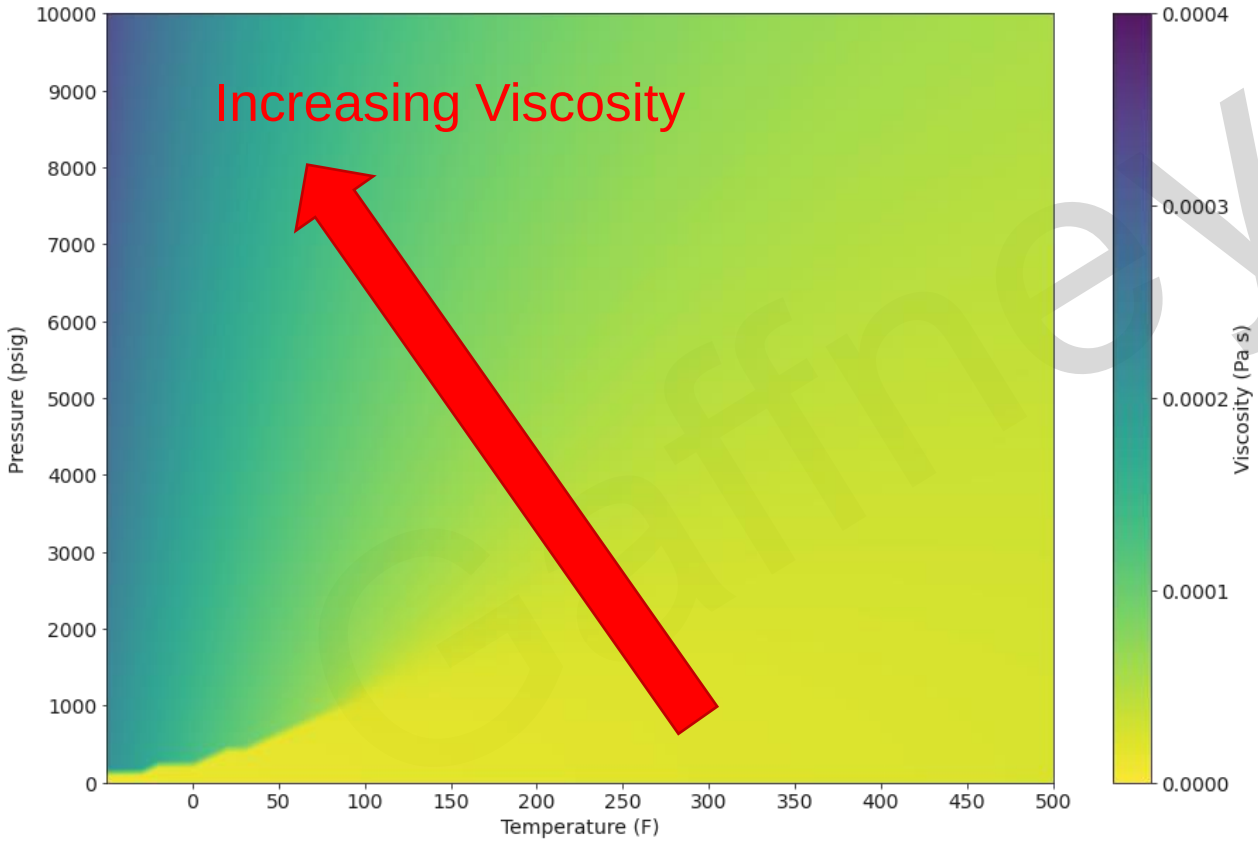
CO_2 Phases

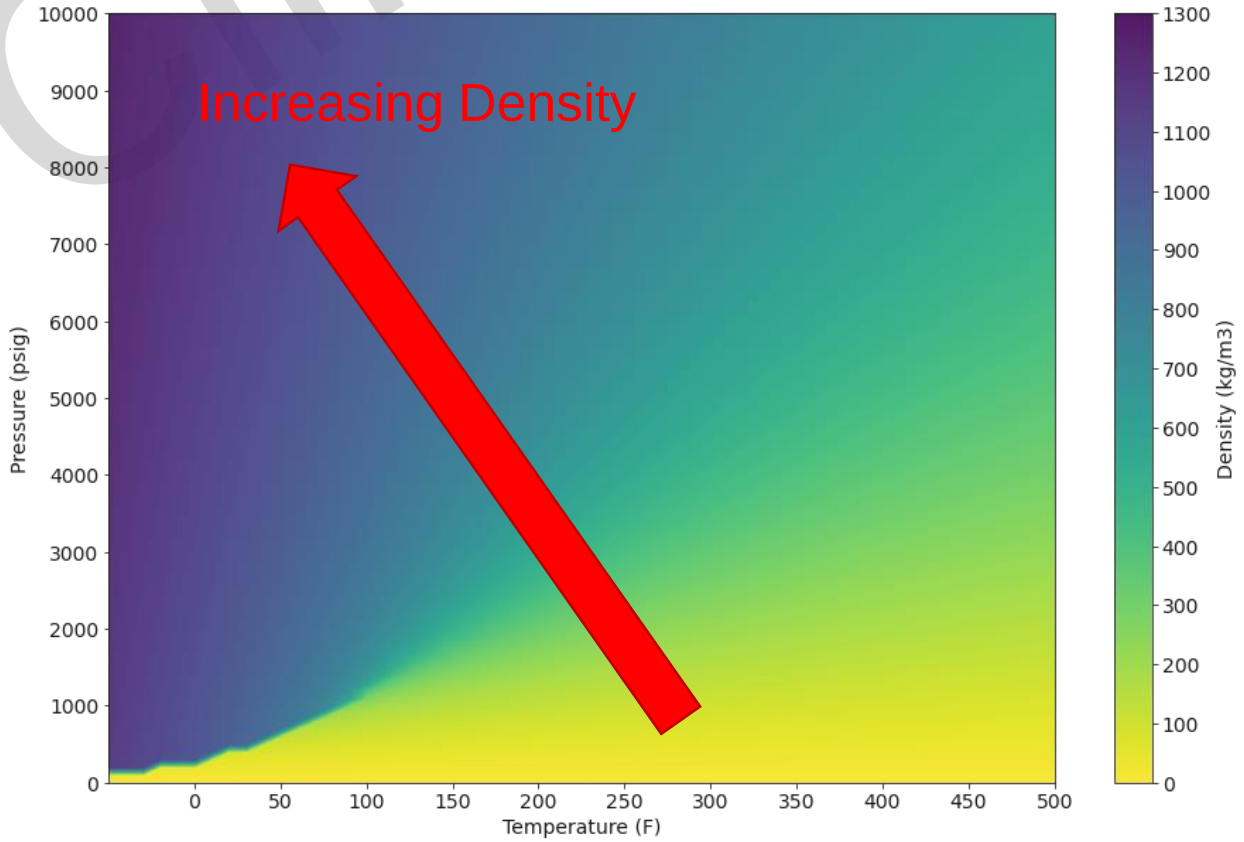
- Most literature emphasizes importance of supercritical state
  - Dense like liquid
  - Flows like gas
- Common screening criterion
  - 800 m rule



CO_2 Density & Viscosity

- Conflicting trends





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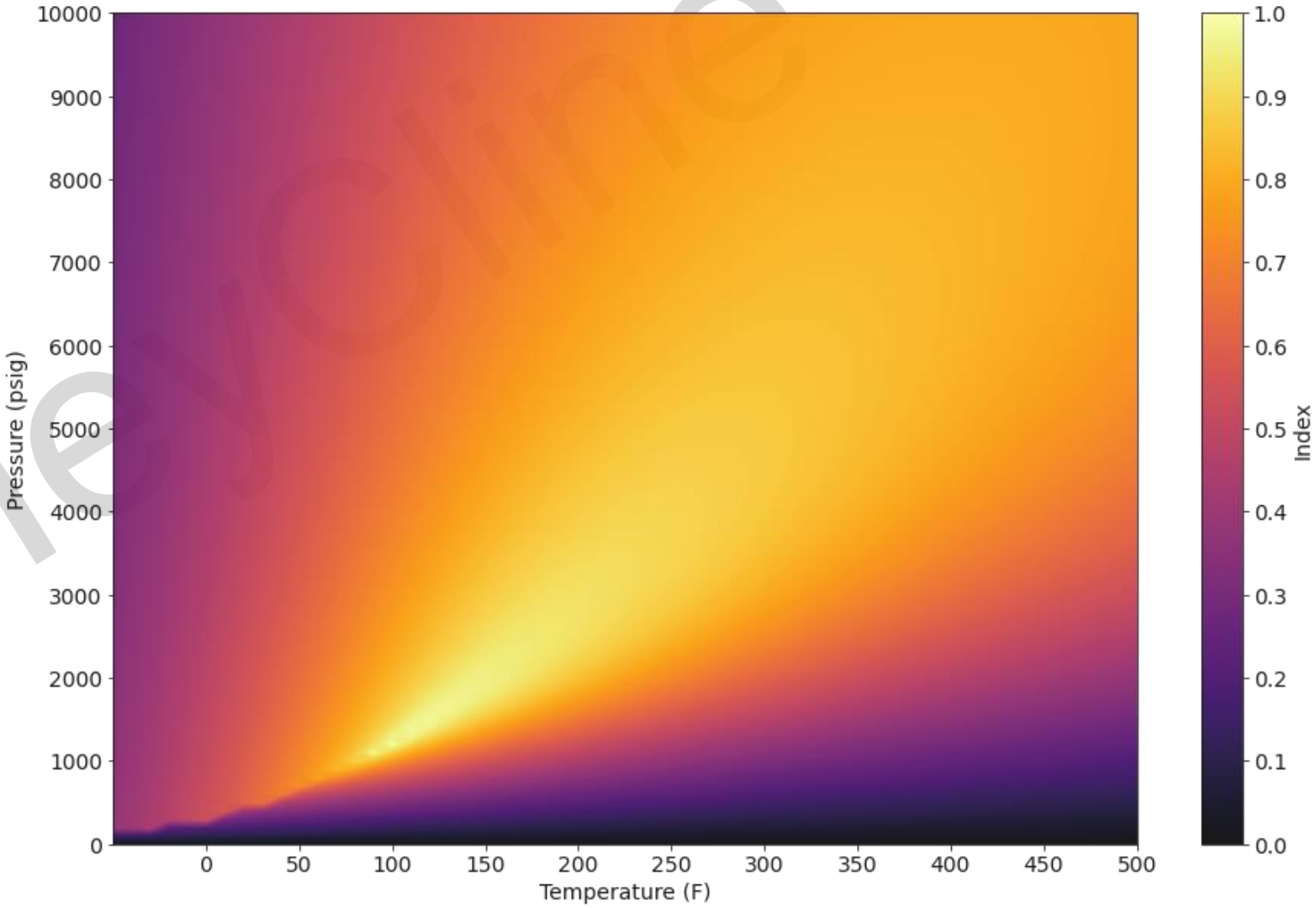
CO_2 Density/Viscosity

- Best balance when CO2 is supercritical



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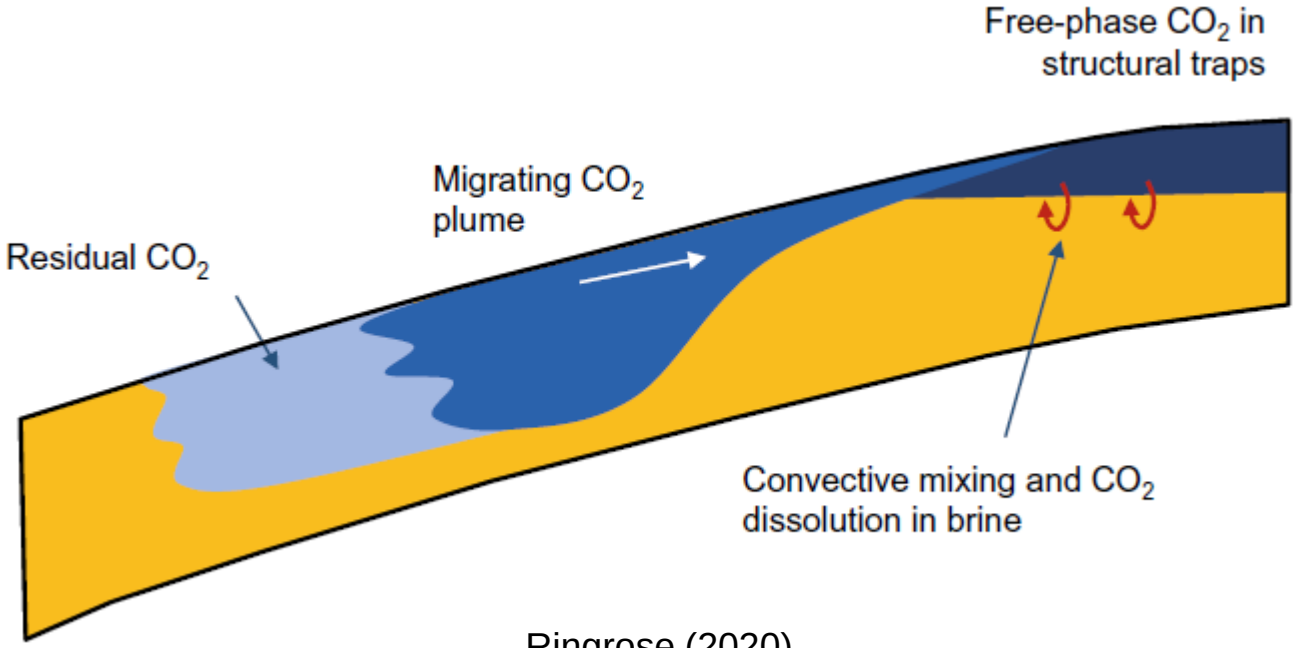
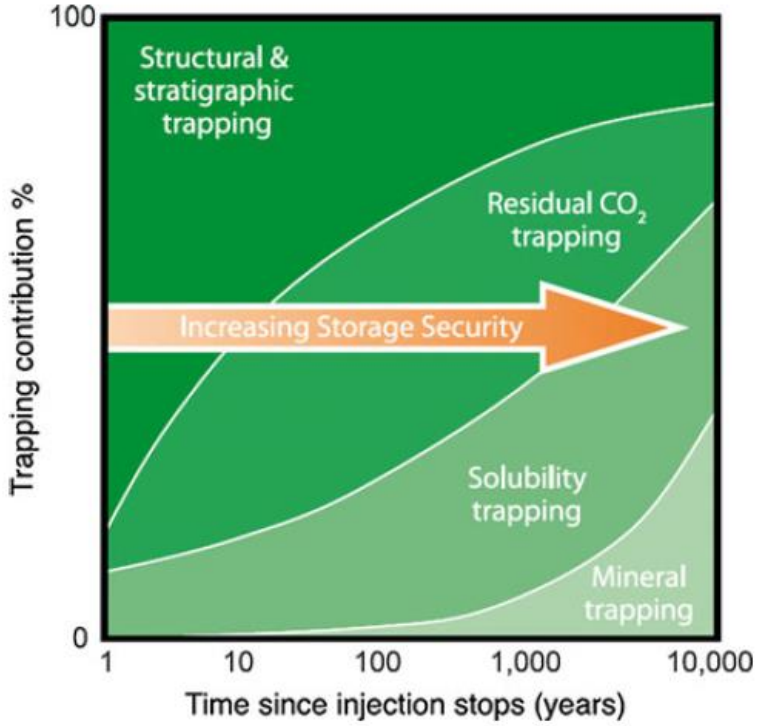
Storage Mechanisms



Ringrose (2020)



Benson et al. (2005)

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Deep Saline Aquifers

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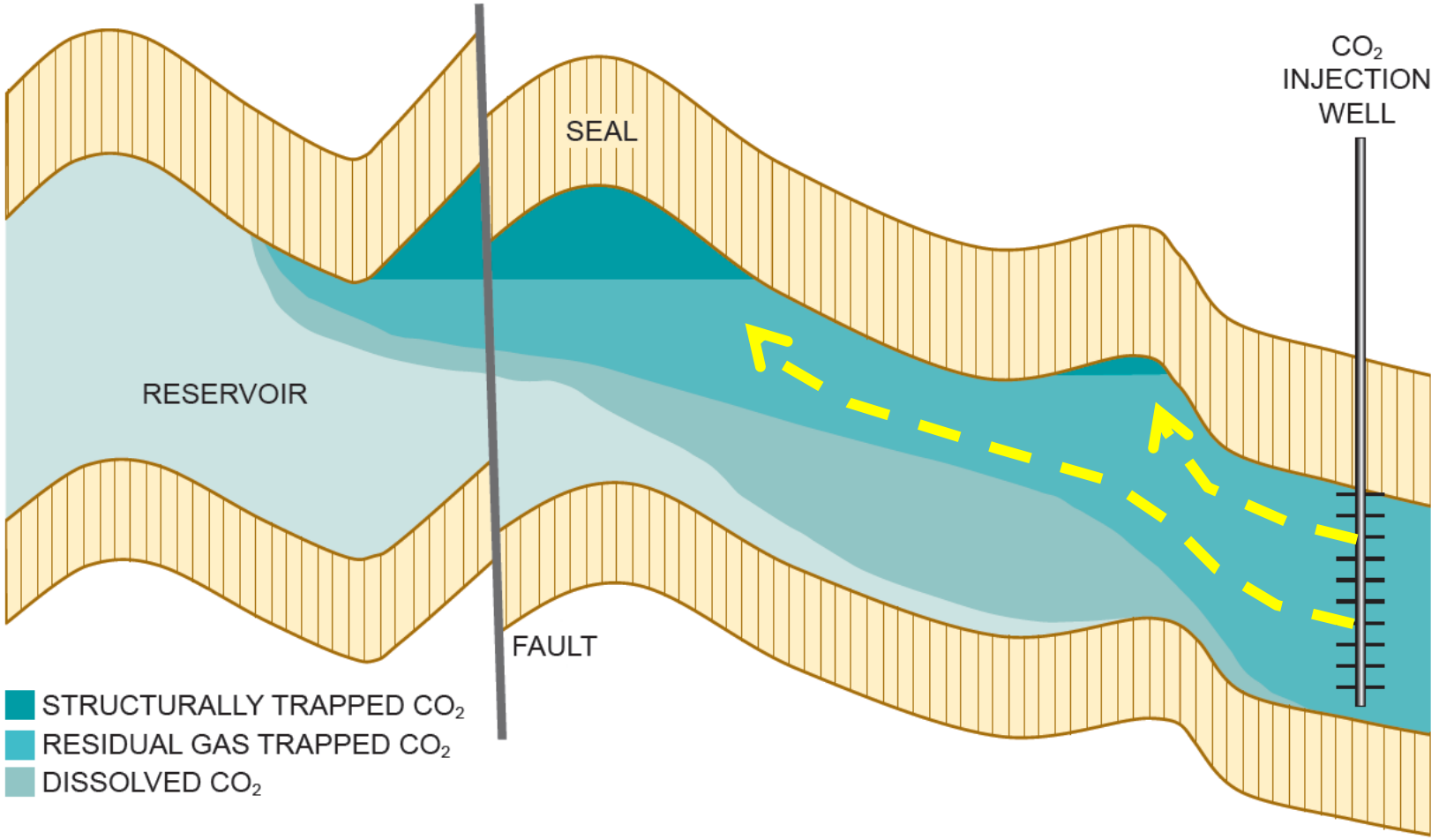
Basic Idea

- Advantages
  - Large
  - Unpenetrated
- Disadvantages
  - Data availability
- Popular examples
  - Sleipner
  - Gorgon



After National Petroleum Council, 2019. Meeting the dual challenge. A roadmap to at-scale deployment of carbon capture, use and storage.

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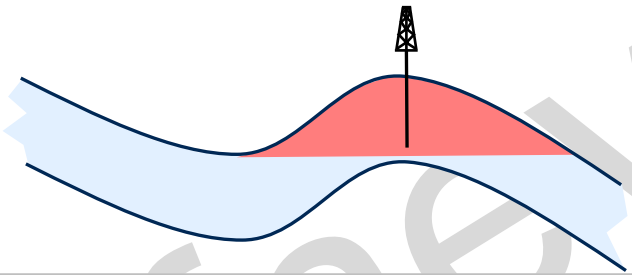
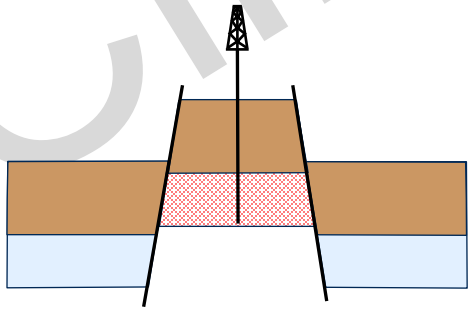
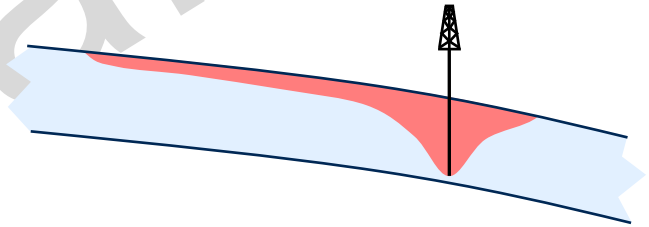
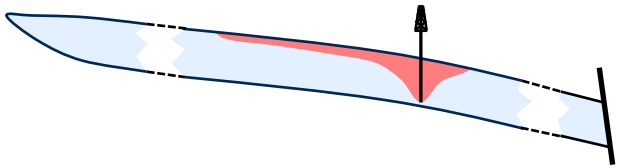
Storage Site Archetypes

	Open Aquifer	Confined Aquifer	
Structural trapping	CO_2 displaces water out of trap. Pressure dissipates 	CO_2 forms a gas cap. Pressure increases in confined space 	Structural trapping
Solubility & residual	CO_2 forms a plume, becoming immobilised. Pressure dissipates 	CO_2 forms a plume, becoming immobilised. Pressure increases 	Solubility & residual
	Open Aquifer	Confined Aquifer	

$EF = (1 - Swir)$ (max)

Expect EF ~ **30 to 40%** of structure PV

Increase by spilling out

$EF = C_t * \Delta P$

Expect EF ~ **0.5%**

Increase with dissolution

Increase with brine extraction

No simple expression for EF

Reported EF ranges typically **0.5% to 7%, (or more)**

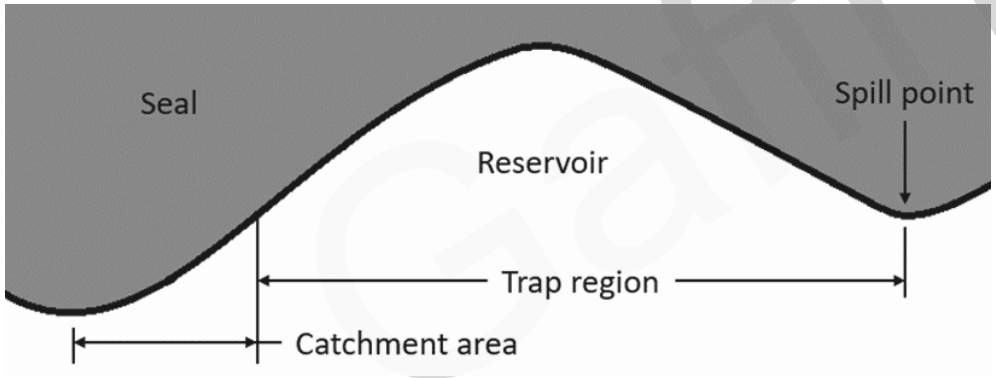
Definition of container determined by development plan

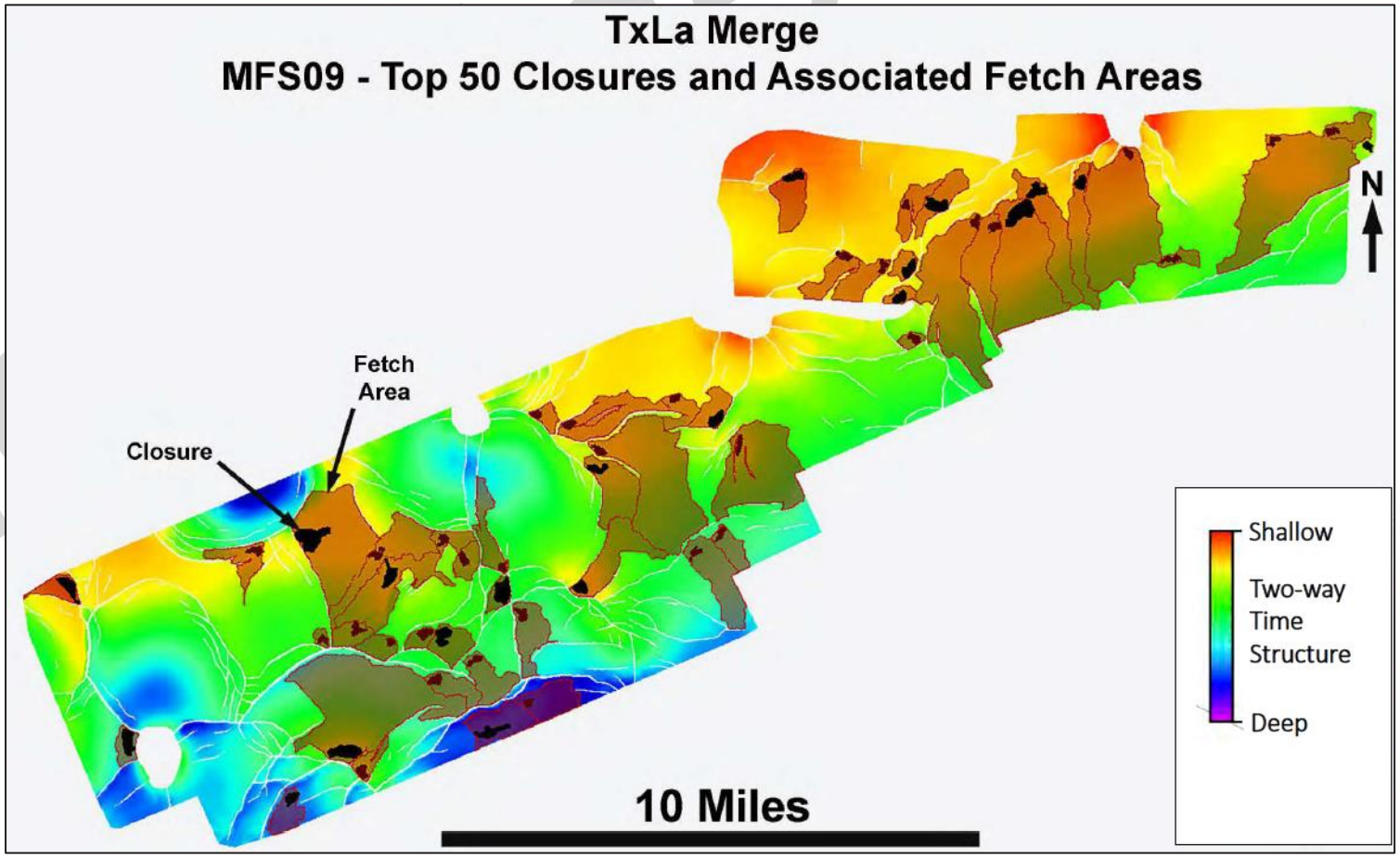
Combination of adjacent two cases

- Adapted from SRMS Application Guidelines Draft 2020

Concept of Catchment

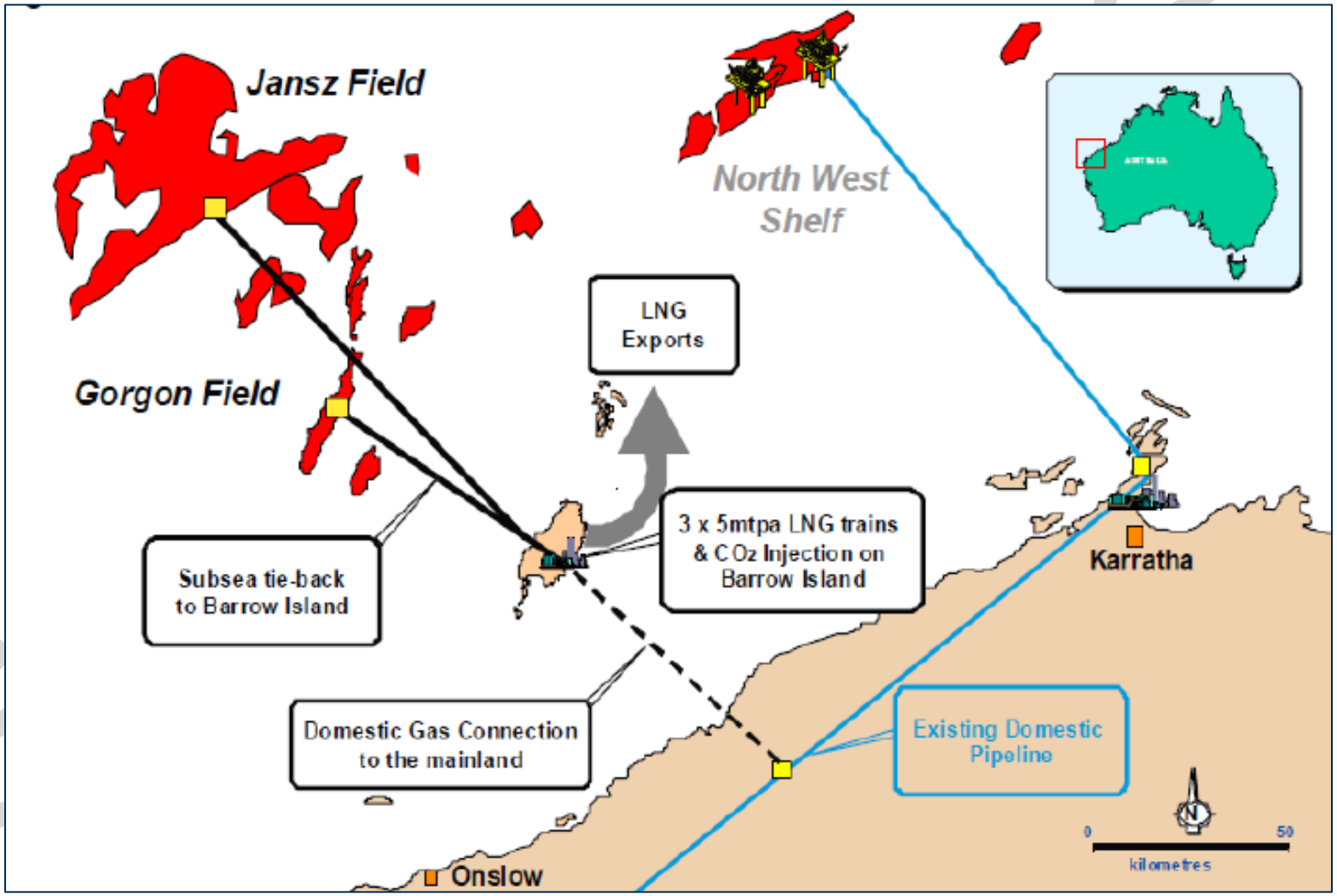
- Storable quantity depends on:
  - Topology
  - Injector location





DeAngelo et al. (2020)

Gorgon CCS Project



Source: Greg Leamon, Site Selection – Gorgon Carbon Dioxide Injection Project

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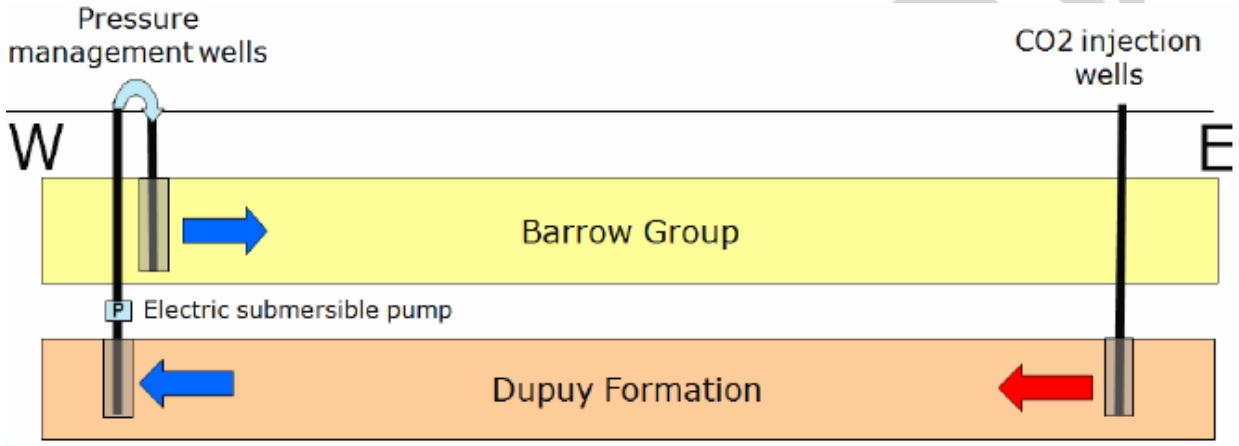
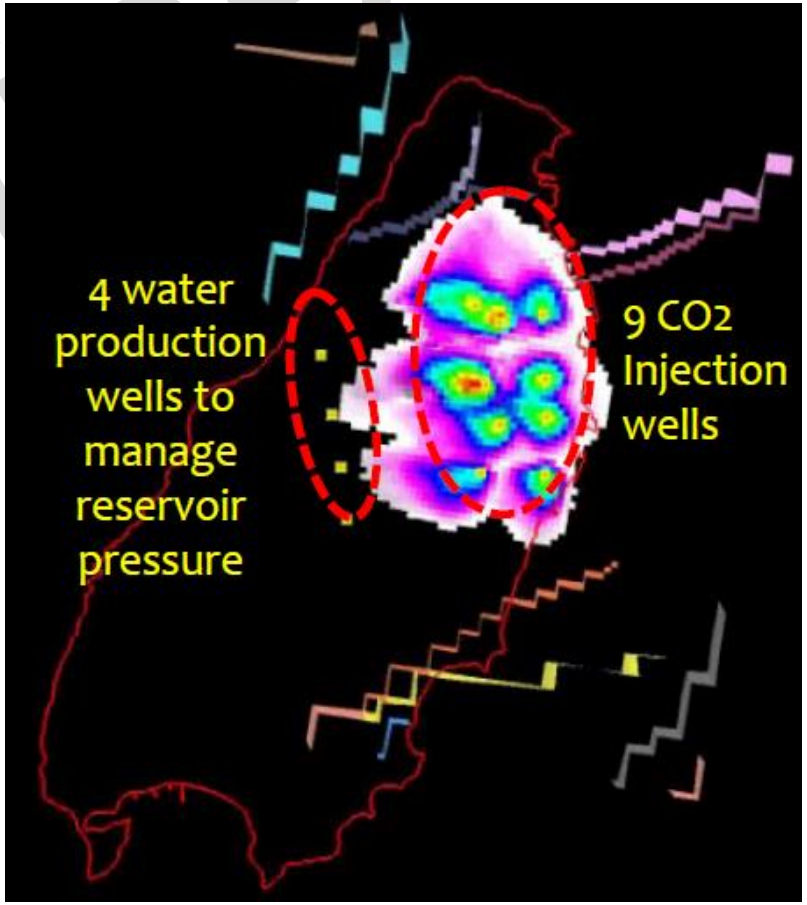
Gorgon CCS Project: Injectivity Woes

- Project has stored >7 million tonnes of CO_2 as of Nov 2022
  - Much lower than planned, over many years
  - Buying offsets to make up for shortfall (~7 Mt)





Sources:
Greg Leamon, Site Selection – Gorgon Carbon Dioxide Injection Project, Upstream Online Feb 2022
Amanda Battersby, Water problems plague world's largest CCS project, Upstream Online Nov 2022

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Depleted Reservoirs

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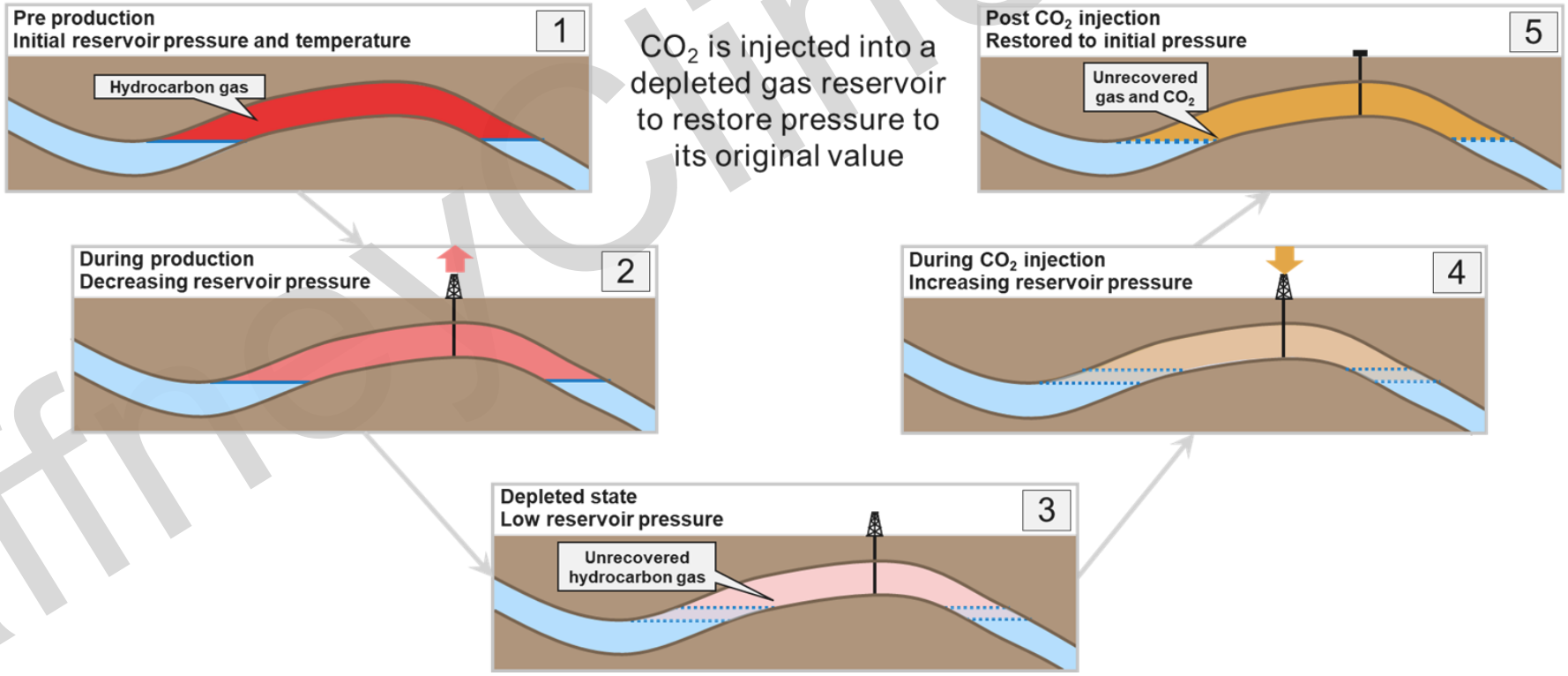
Basic Idea

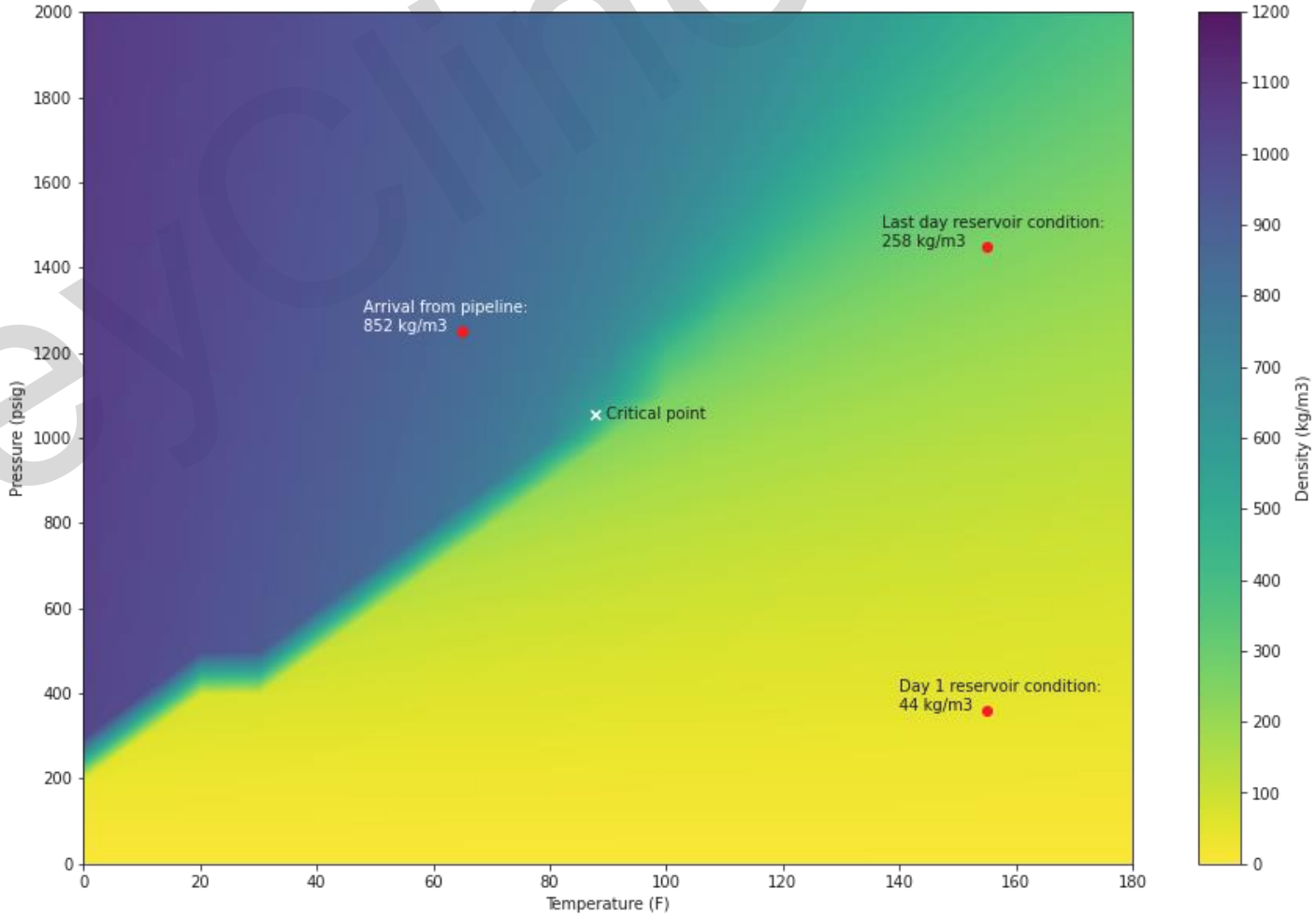
- Advantages
  - Proven seal
  - Infrastructure
  - Data availability
- Disadvantages
  - Legacy wells
  - Usually smaller
- Examples
  - Moomba
  - Kasawari



Peacock (2023)

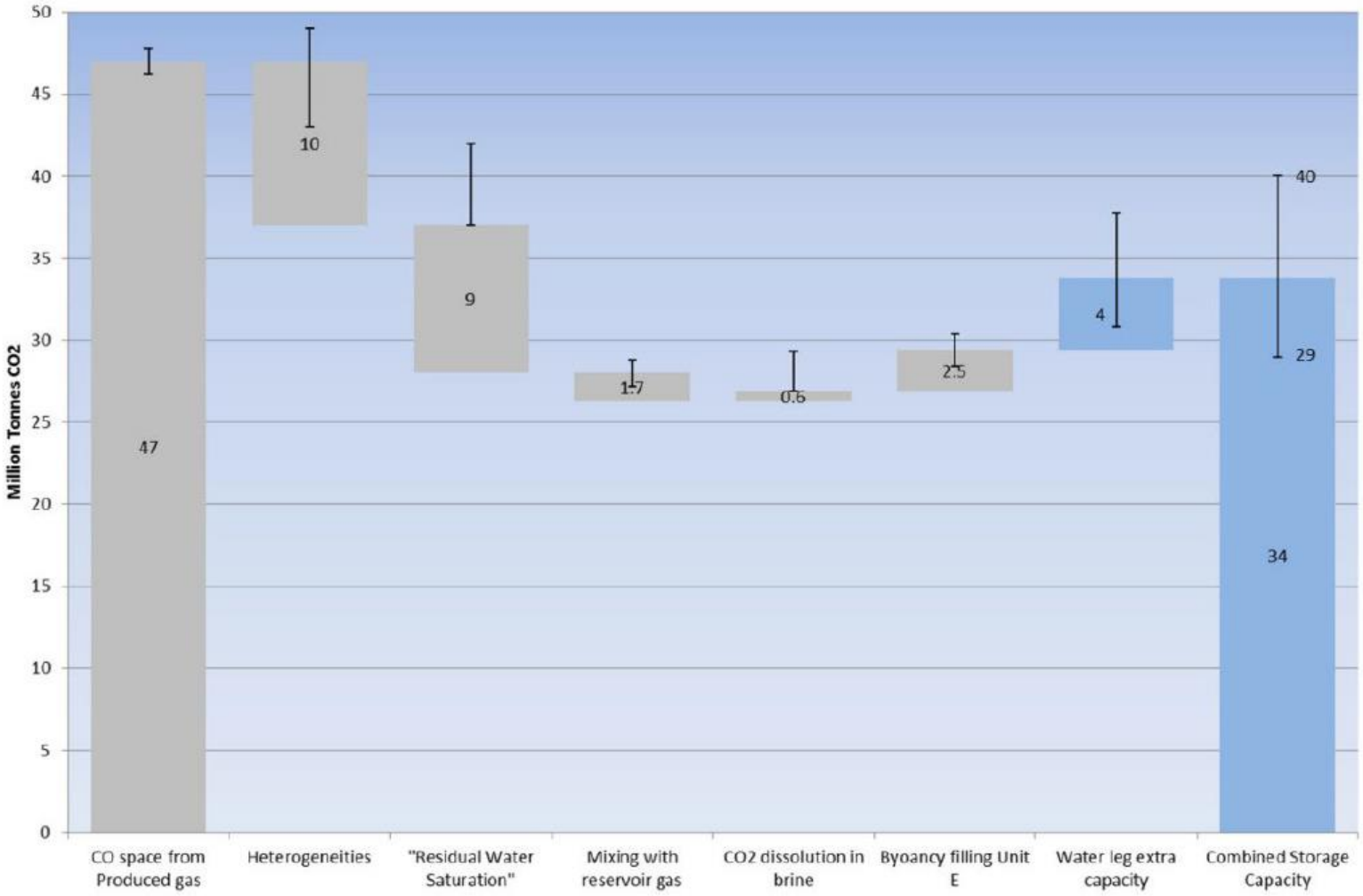
Big Pressure Transitions

- Two injection approaches
  - Liquid/supercritical injection
    - Higher well rates
    - Hydrate formation
    - Thermal fracturing
  - Gas injection
    - Lower well rates
    - Costly surface equipment
    - Lower risk of reservoir damage



Factors affecting Storable Quantity

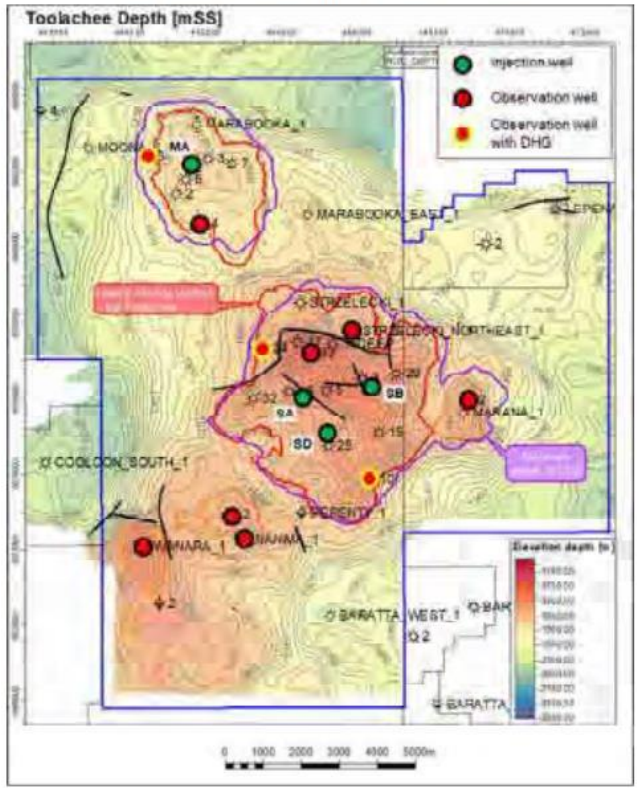
- Cumulative production is the dominant factor
- Storable quantity estimated from voidage replacement calculation is an ideal case



Shell (2014); from SPE SRMS guidelines (2022)

Moomba CCS Project

Figure 5.56: Top Structure Map of Toolachee Formation



The Santos plan is to utilize the depleted gas reservoir in the Toolachee sandstone formation (**Figure 5.55**) of the Strzelecki and Marabooka anticlinal structures during Phase 1a. These structures have the combined capacity to store between 13 and 14 Mt of CO2 (gross), at an injection rate of approximately 1.7 Mtpa over eight years. Santos plans to drill three new storage wells on the Strzelecki structure and one well in Marabooka and has made provision for two contingency wells in Strzelecki and one in Marabooka.

Source: ITSR for OilSearch and Santos Merger (Part of merger scheme booklet)

Santos announces booking of CO2 storage capacity

Santos today announced a booking of 100 million tonnes of CO2 storage resource in the Cooper Basin in South Australia.

This represents a subset of the total prospective storage resource in the Cooper Basin and follows the final investment decision on the 1.7 million tonne per annum Moomba carbon capture and storage (CCS) project in November 2021.

Santos believes this is the first booking in the world in accordance with the CO2 Storage Resource Management System (SRMS) sponsored by the Society of Petroleum Engineers.

Source: Santos, 8 Feb 2022

Sustainable Business

2 minute read · October 1, 2021 2:24 PM GMT+8 · Last Updated 2 years ago

Australia to issue credits for carbon capture

By Sonali Paul

Source: REUTERS

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CO_2 Storage Resources Management System

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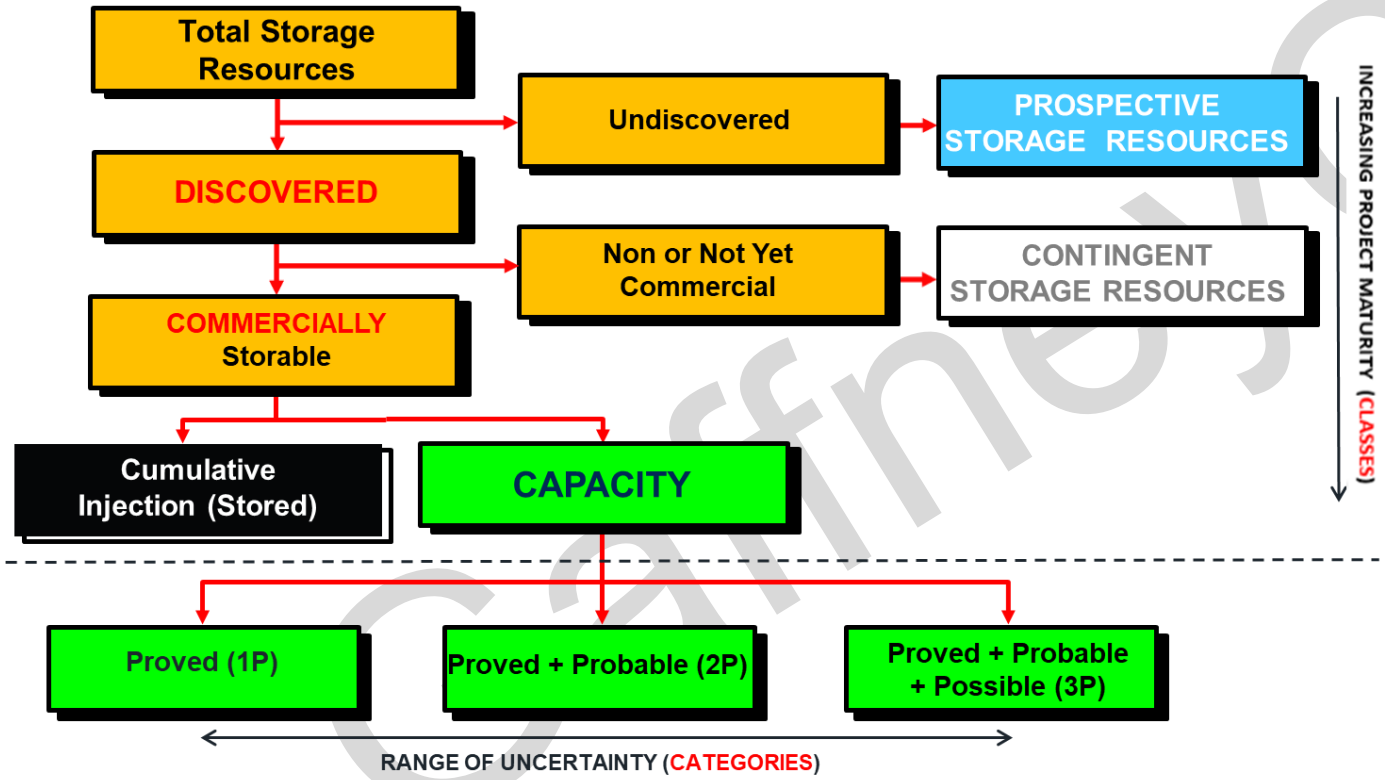
CO_2 Storage Resource Management System (SRMS)



SPE CO_2 SRMS

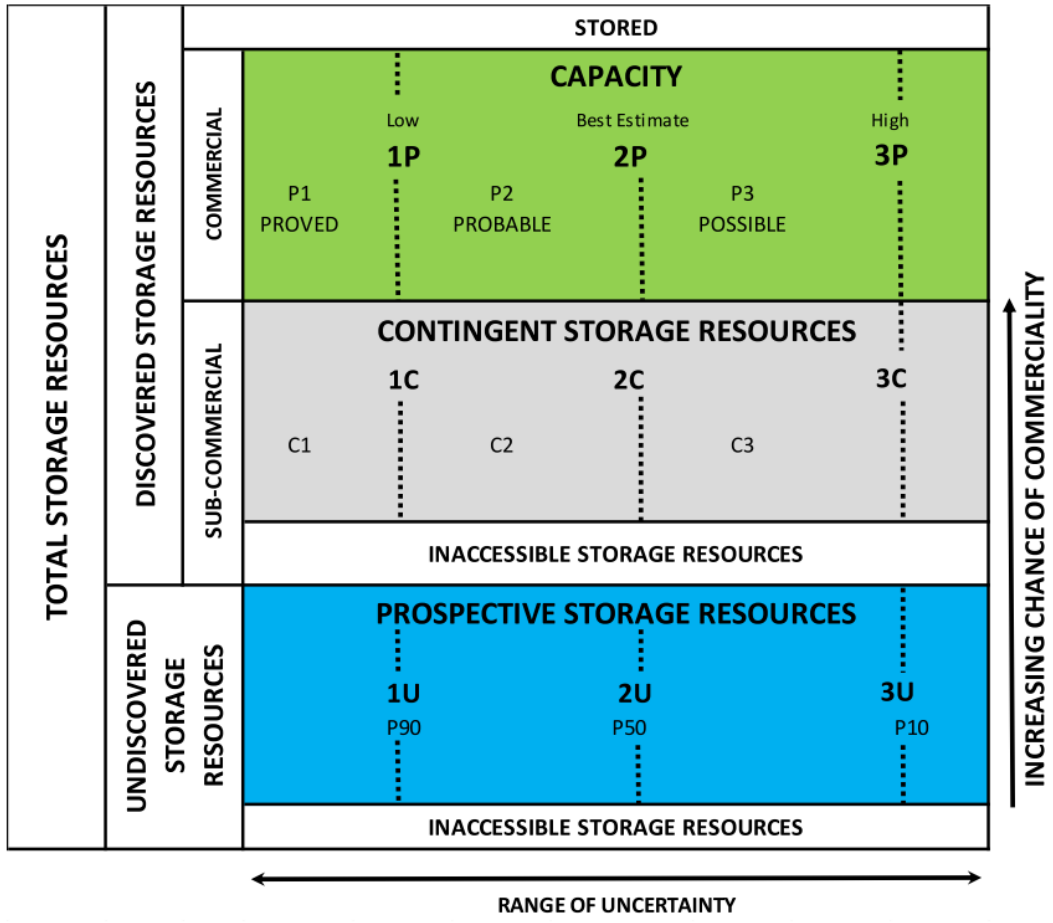


Fig. 1.1 – Resources Classification Framework

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Summary

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Summary

- CO_2 storage in saline aquifers or depleted reservoirs
  - Pros and cons in each
- Storage in dense phase is preferred
- Four main storage mechanisms: structural, residual, dissolution, mineralization
- Saline aquifers or depleted reservoirs have unique technical challenges
- SRMS provides common language for reporting storable quantities

Acknowledgements

- Andrew Duncan – Director
- Doug Peacock – Senior Director
- Peter Adam – Principal Advisor