CCUS - Storage
Examples and Learnings from Saskatchewan

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Chief Operating Officer

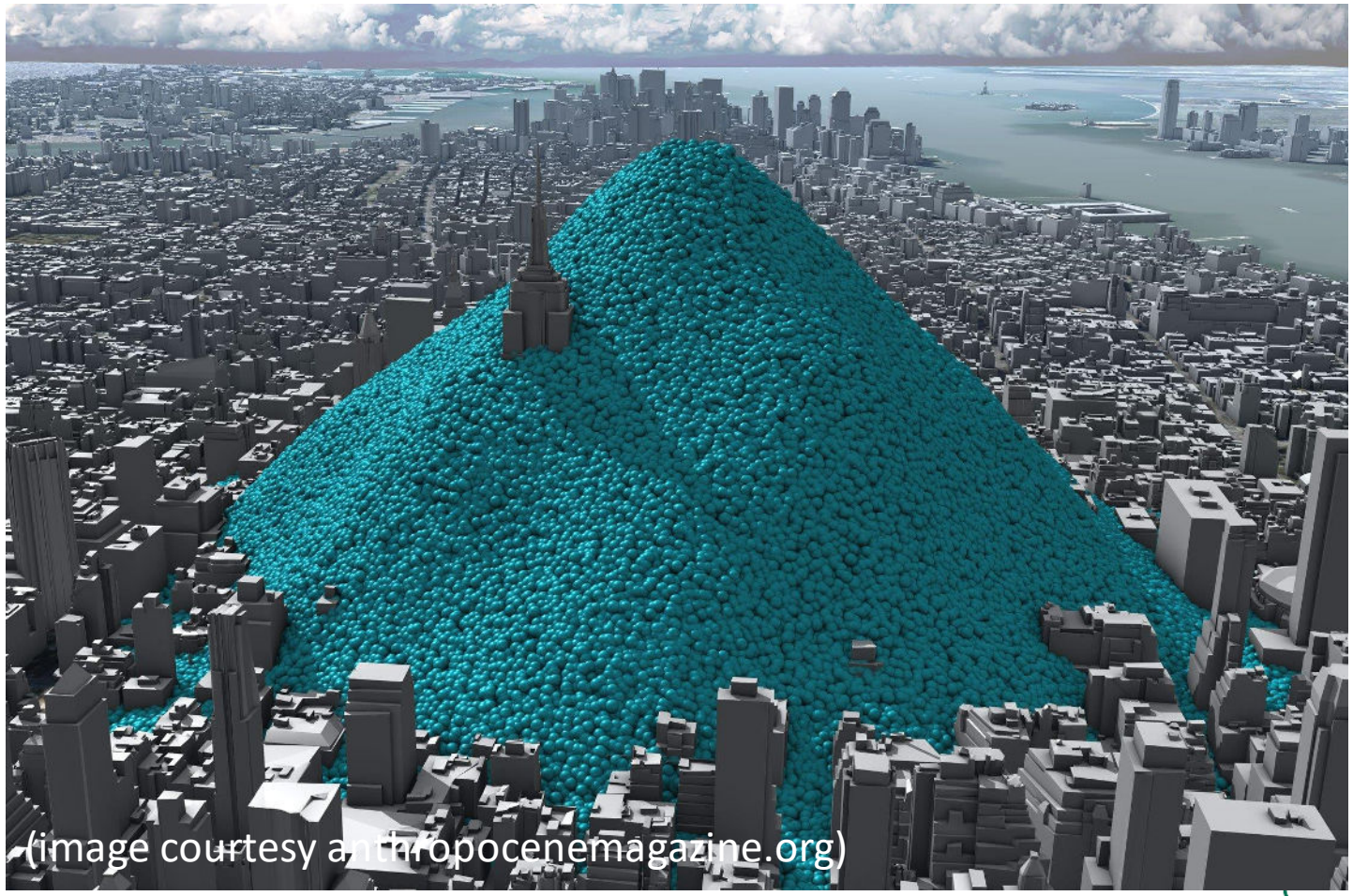
PTRC

Outline

- CO_2 Properties
- Subsurface Geology
  - CO_2 Storage
  - Reservoirs
  - CO_2 Enhanced Oil Recovery
  - Storage Capacity
- Site Selection
- Well Construction and design
- The Aquistore Project
  - Site Selection
  - Well Design
  - MMV

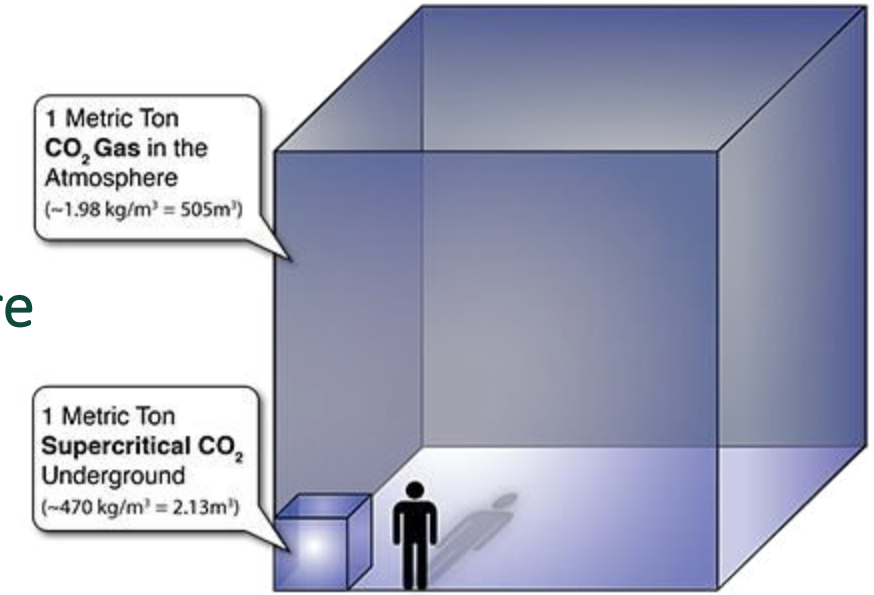
Some CO_2 facts

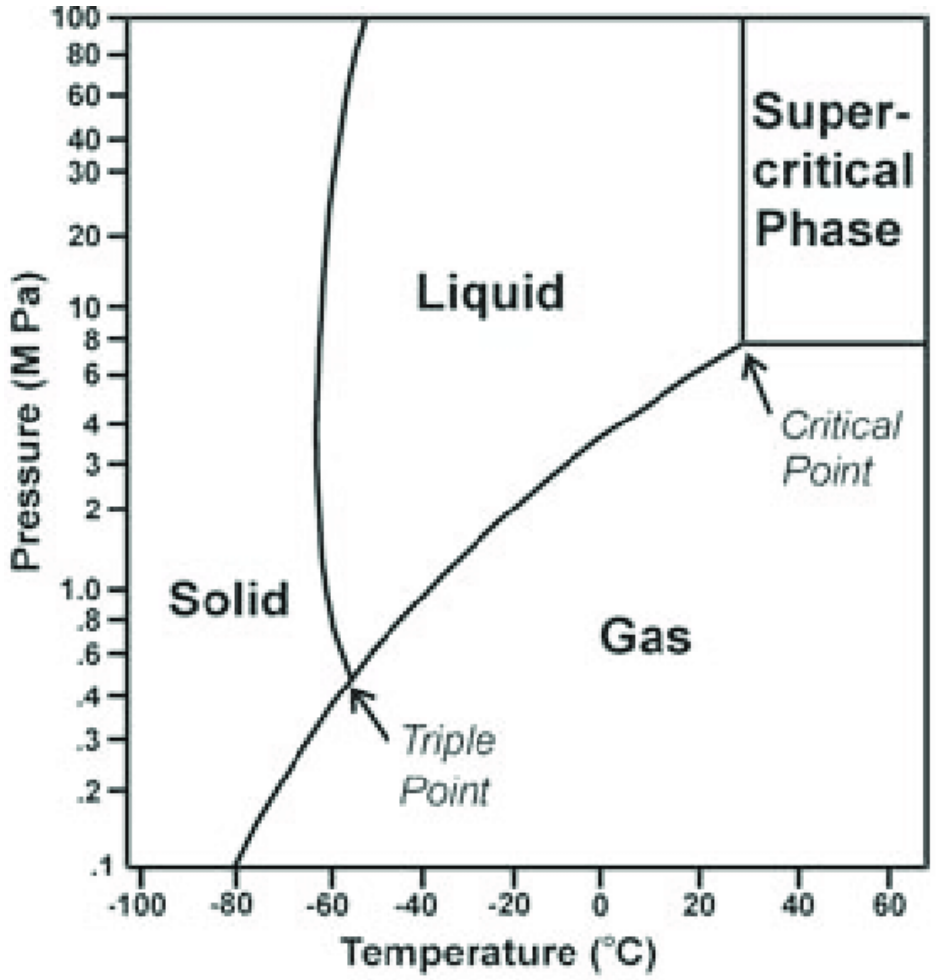
- CO2 is Captured from not only coal plants, but cement plants, refineries, fertilizer plants, ethanol facilities and more.
- A tonne of CO2 will fill a 27 foot cube
- You will create about 14 Tonnes a year
- Example: NYC emits about 150,000 tons/day



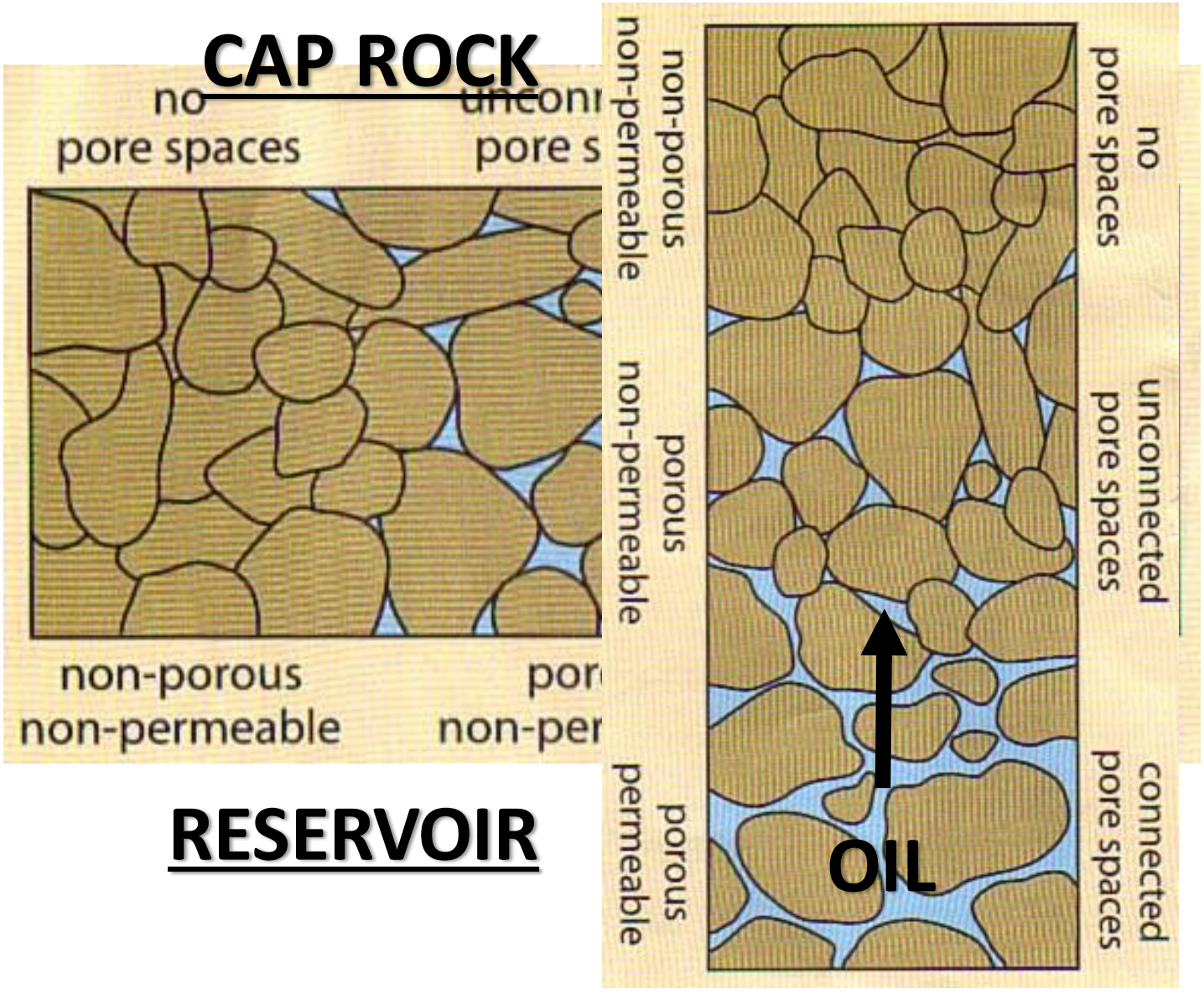
Some CO2 Facts

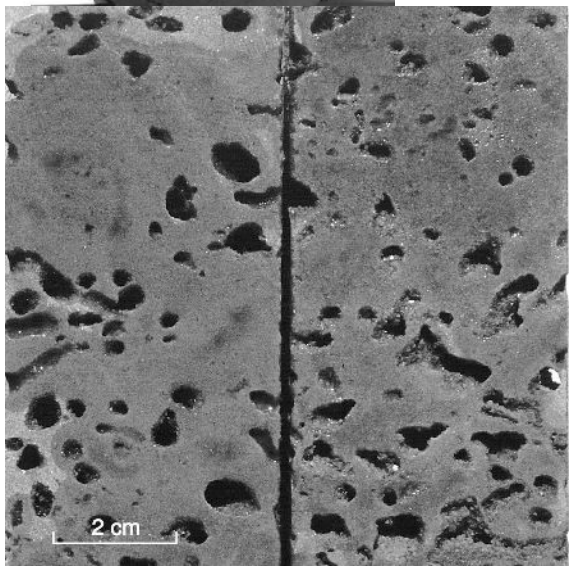
- Compressing the CO2 is important for storage efficiency
- “Supercritical” zone becomes important to achieve pressure
- CO2 Purity is required



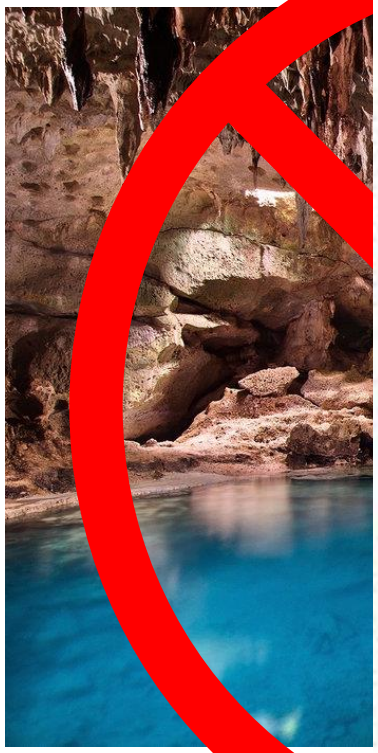


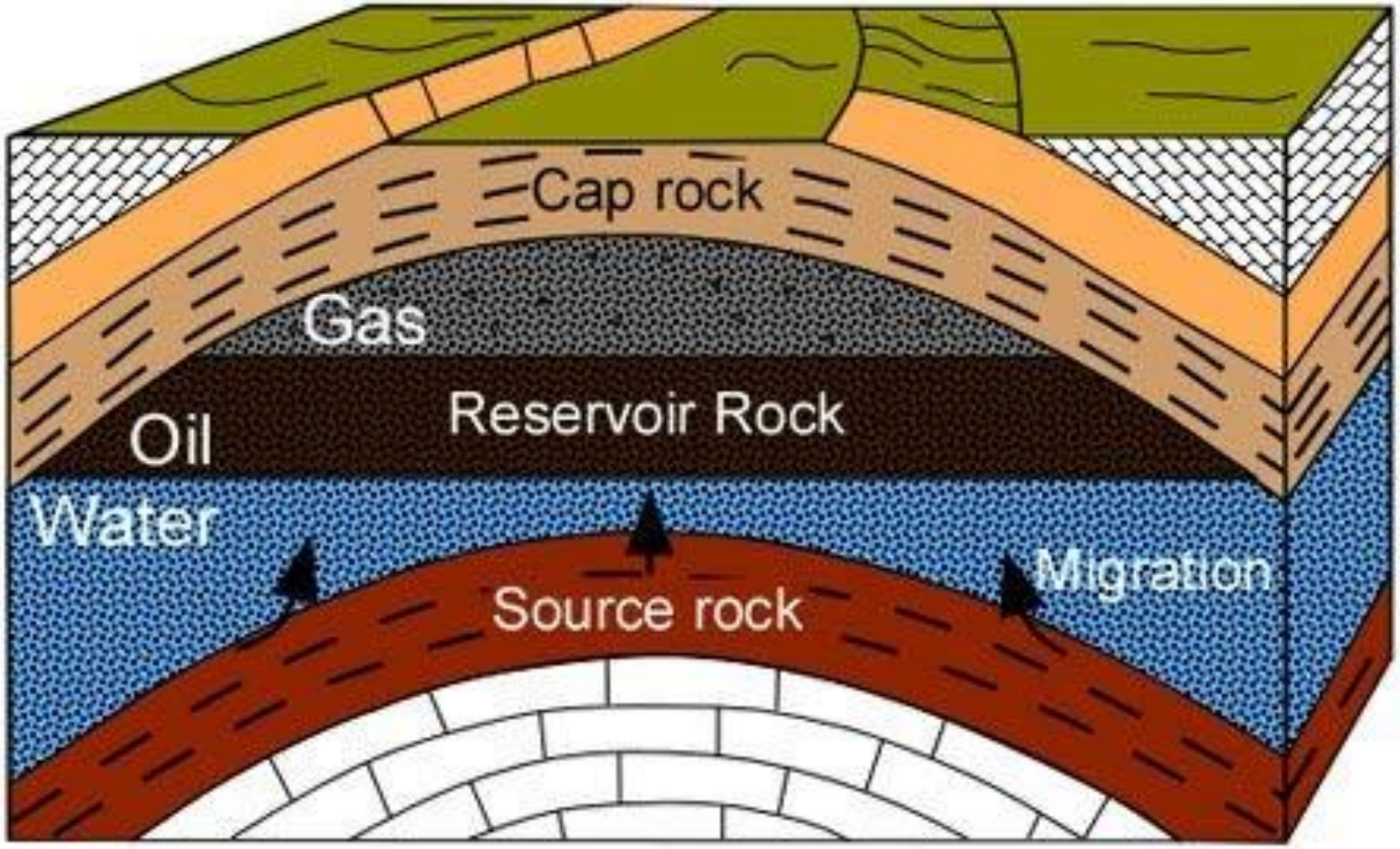
Reservoir Rock



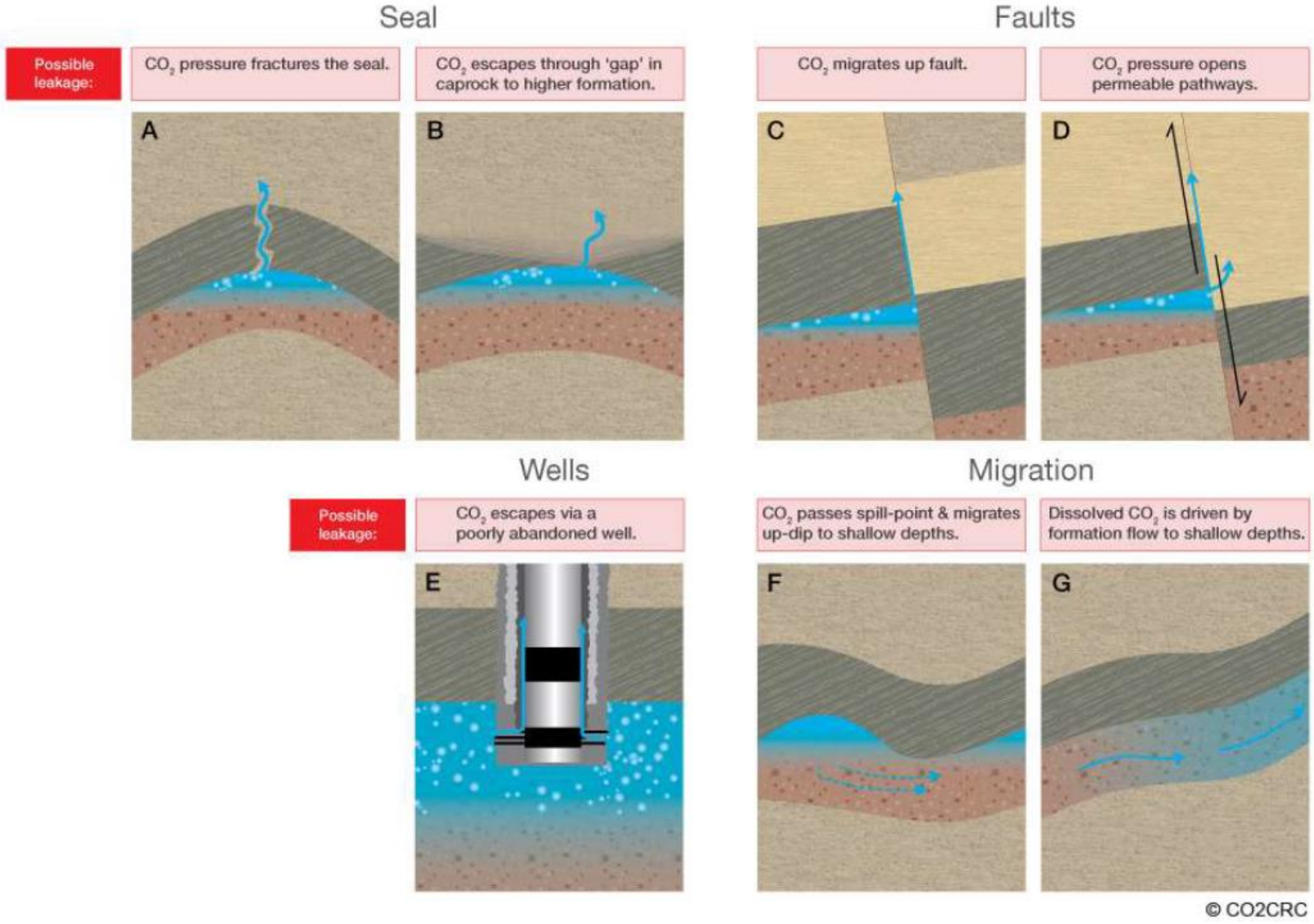


What is a Reservoir?





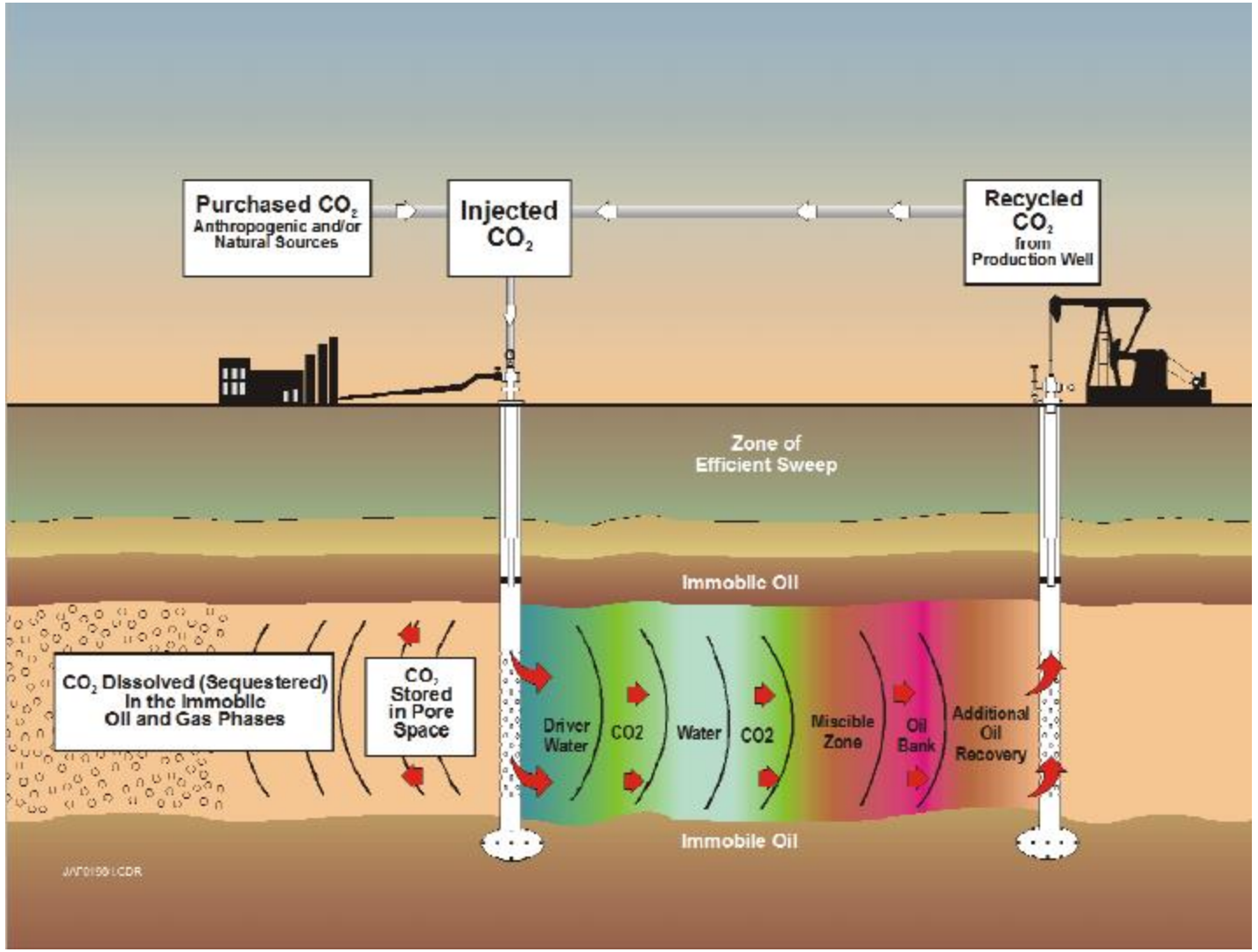
Can it leak?


Seal
Faults
Possible leakage:
CO_2 pressure fractures the seal.
CO_2 escapes through 'gap' in caprock to higher formation.
CO_2 migrates up fault.
CO_2 pressure opens permeable pathways.
A
B
C
D
Wells
Migration
Possible leakage:
CO_2 escapes via a poorly abandoned well.
CO_2 passes spill-point & migrates up-dip to shallow depths.
Dissolved CO_2 is driven by formation flow to shallow depths.
E
F
G
© CO2CRC

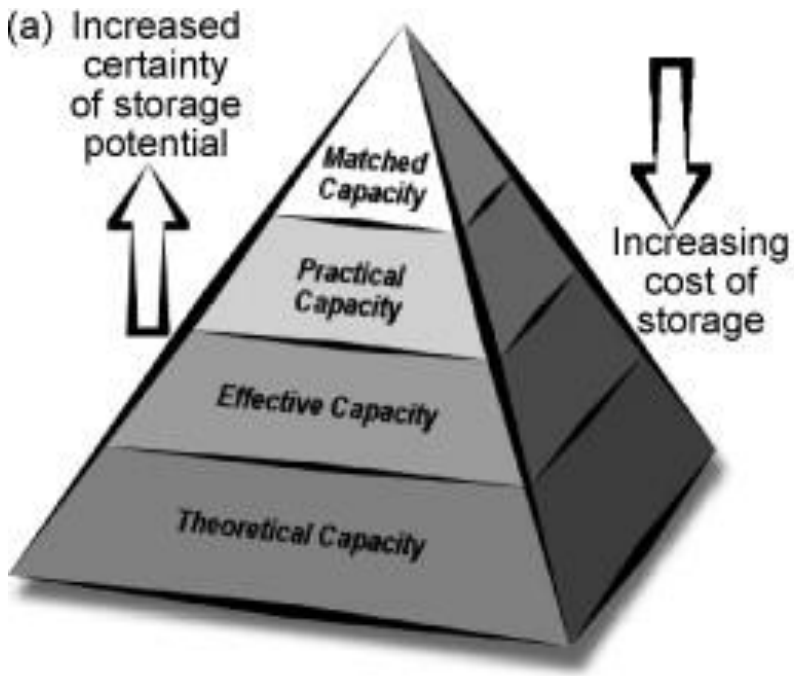
CO2 Storage and EOR

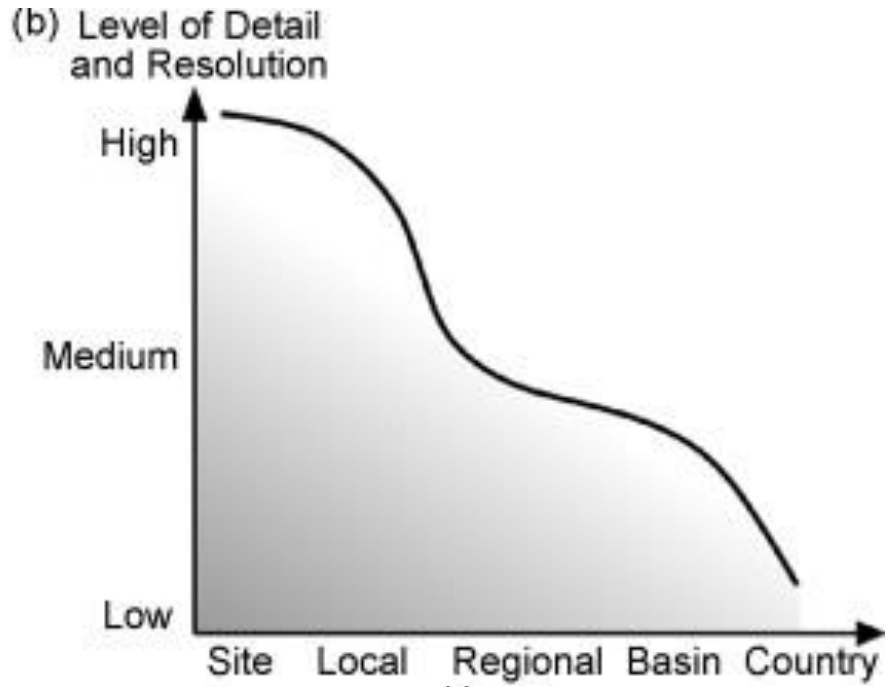
- Most EOR is running miscible CO_2 from one well to another, often in complicated patterns
- "Supercritical" CO_2 becomes important to achieve miscibility with the oil
- "WAG" is alternating water with the CO_2 to build up an "oil bank"
- Emissions intensity for CO2EOR derived oil is lower than most other production methods

(Azzolina, 2016 "How Green is my oil?")

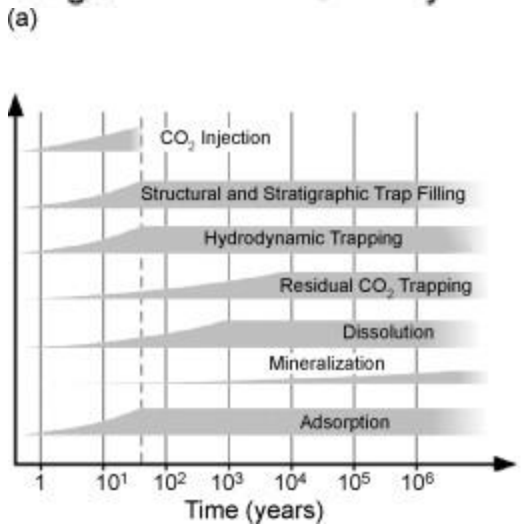


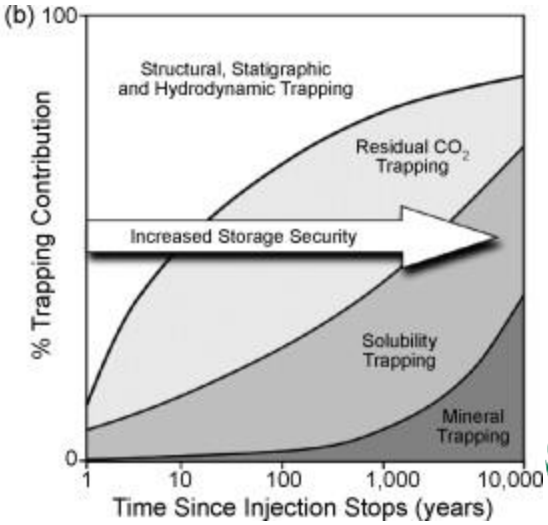
How Much can be stored?





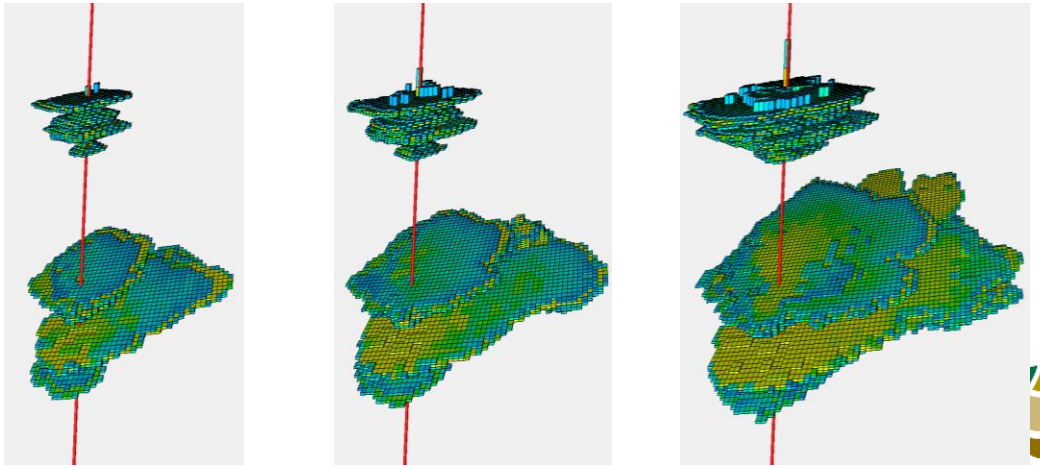
- Storage Volume dependent upon many factors
- Theoretical to actual matched capacity are very different
- Storage happens in different ways



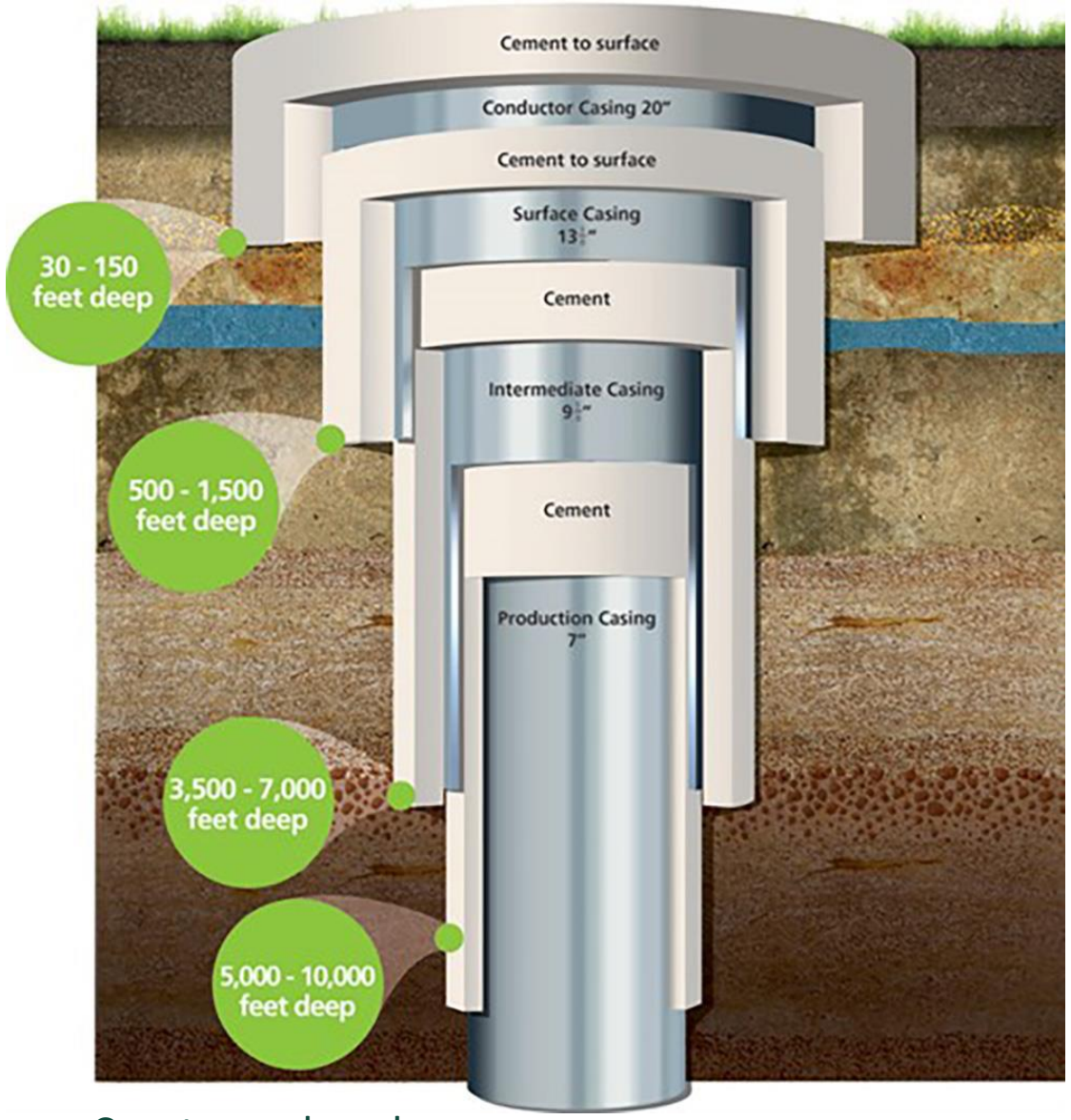


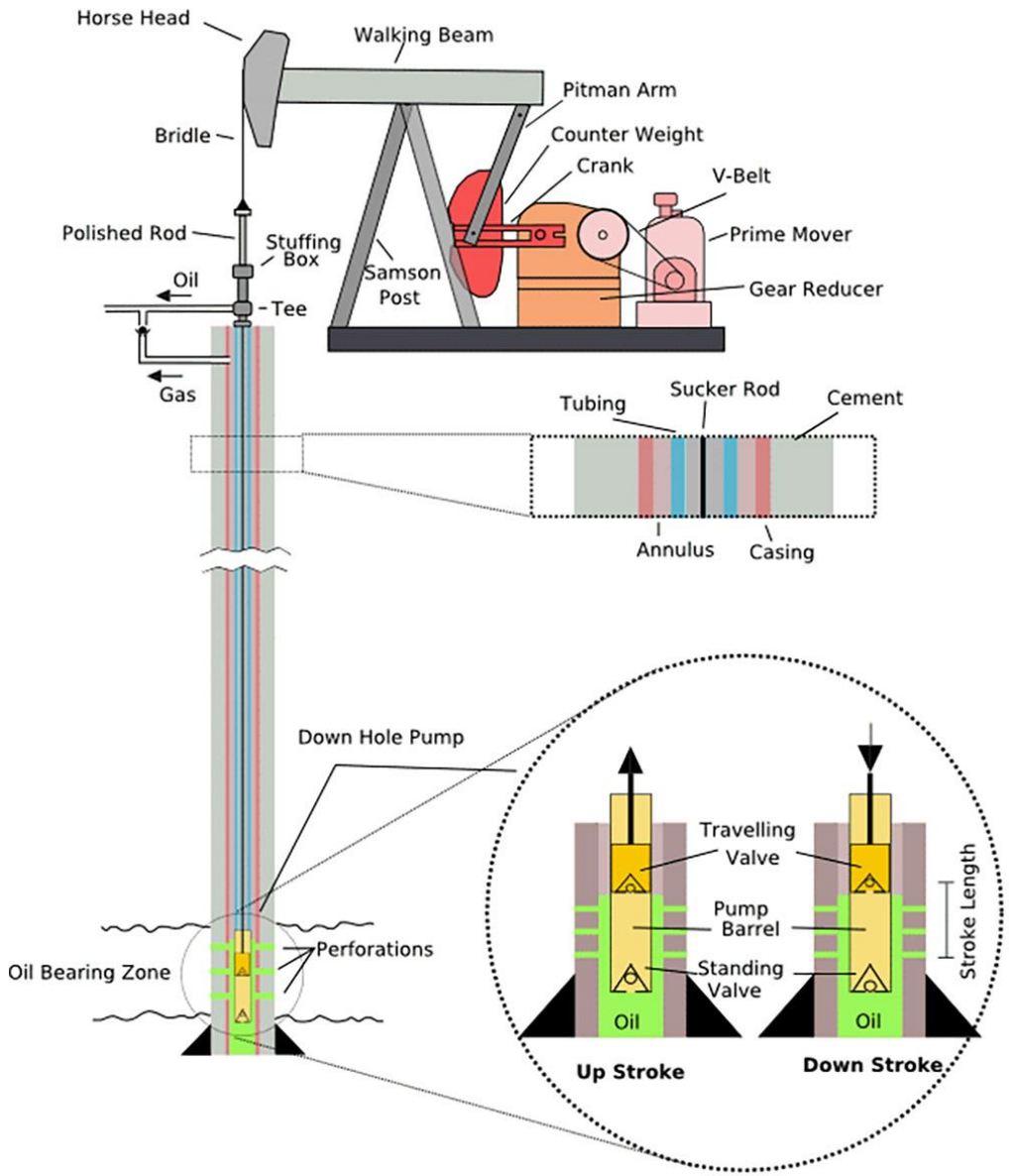
Site Selection Considerations

- Suitable Geology
  - Porosity under a seal
  - Depth greater that 1000m
  - Volume considerations
- Proximity to source
  - Pipeline approximately $1million per km
  - Rail a possibility but for smaller emissions
- Pore Space Ownership
- Suitable Surface conditions



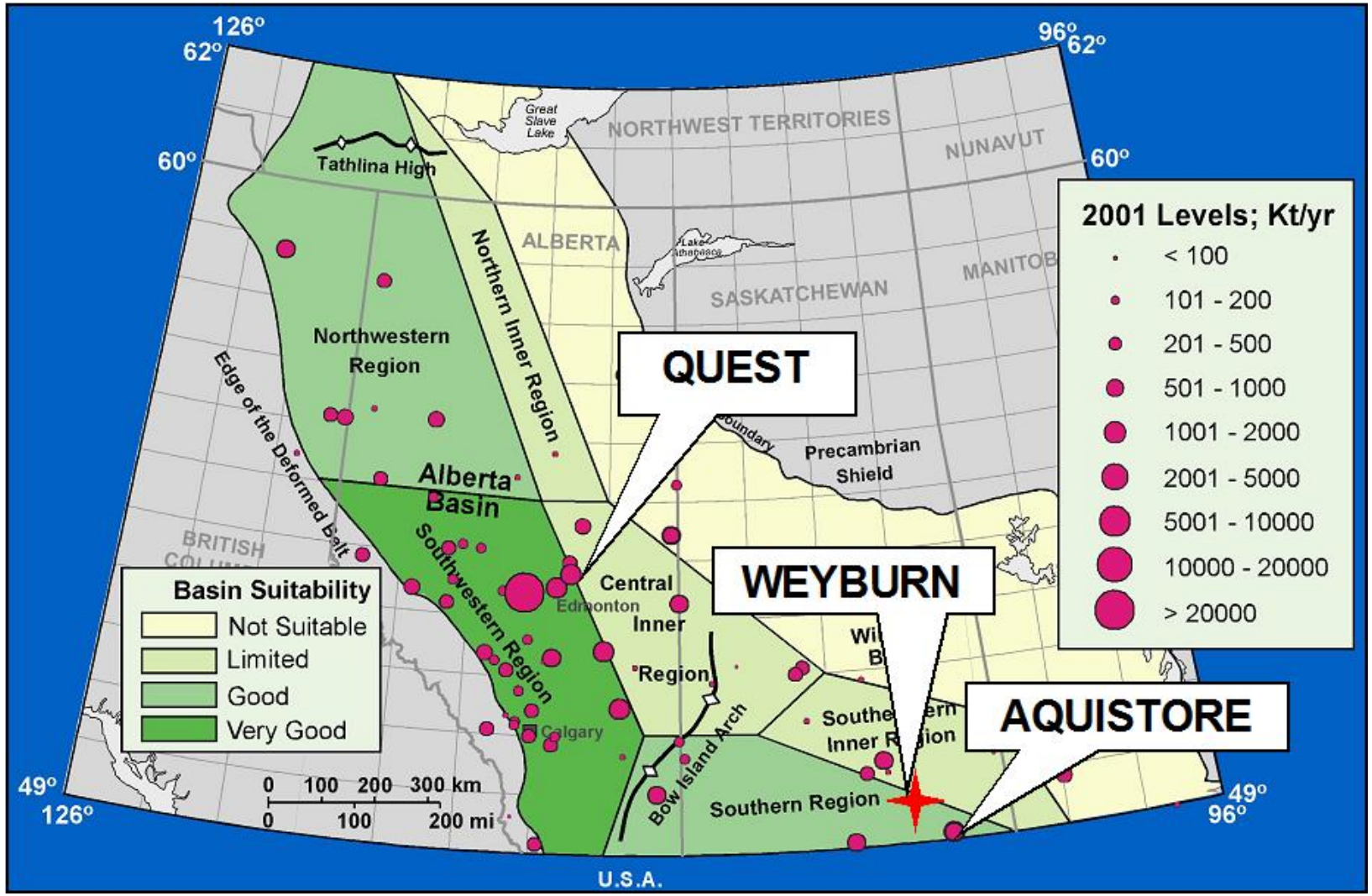
Anatomy of an oil (or CCUS) well





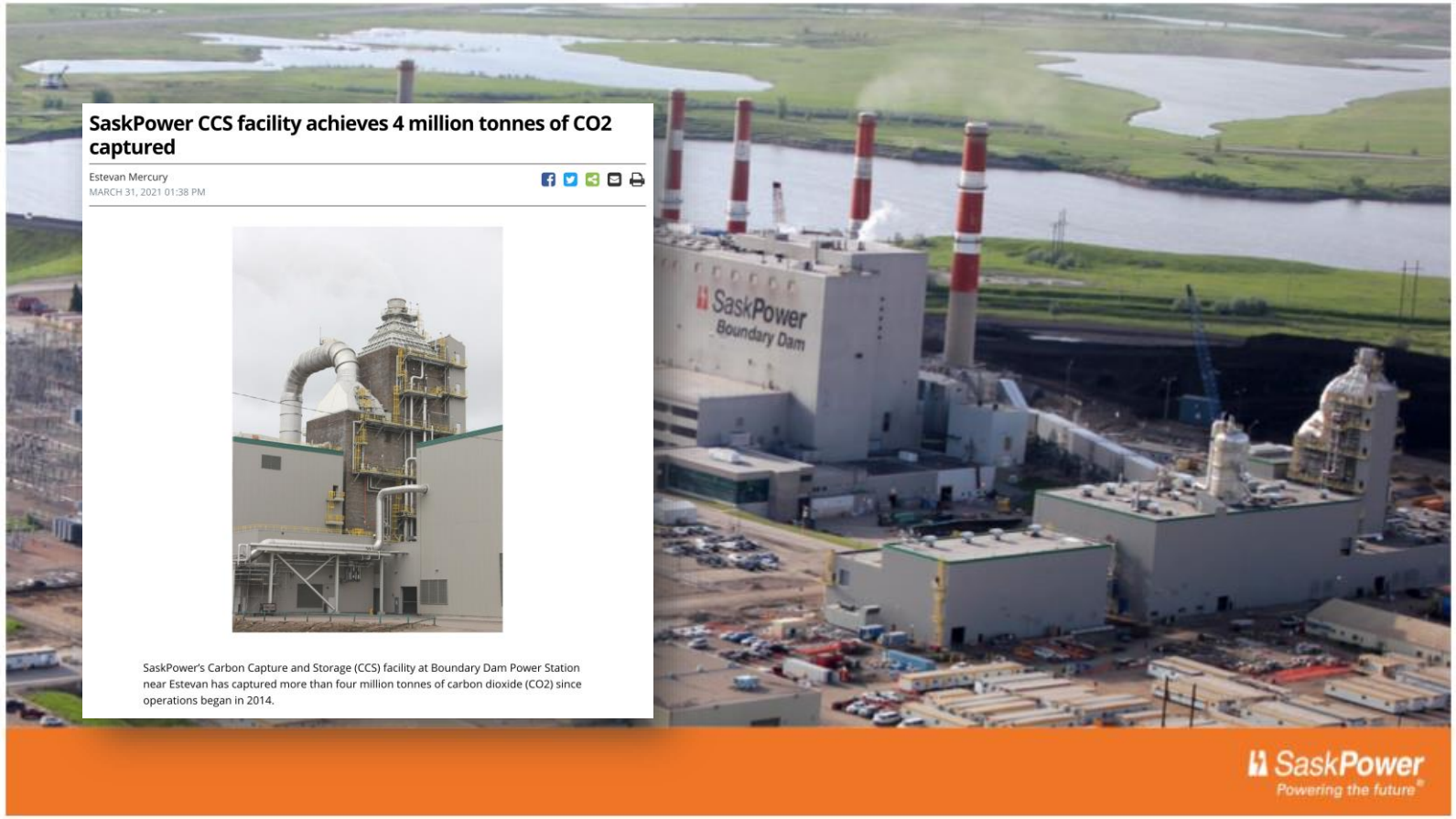
Images Courtesy: ukogplc.com

Injection Suitability



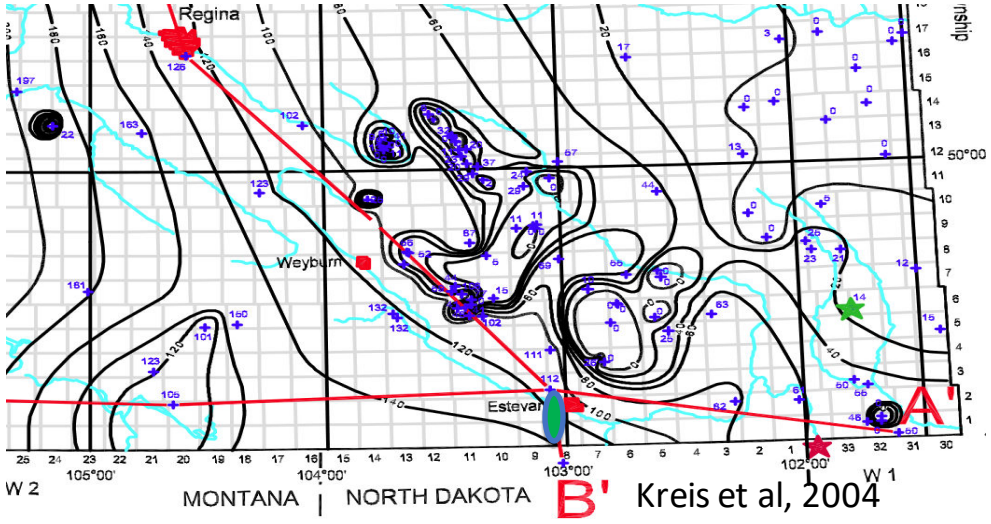
Aquistore/Boundary Dam Background

- CCS plant in lower right
- Each stack represents a "unit" at the plant
- Line from Unit 3 seen running to CCS plant
- Decision to build was in 2008
- Wells drilled in 2012
- Producing CO2 in 2015



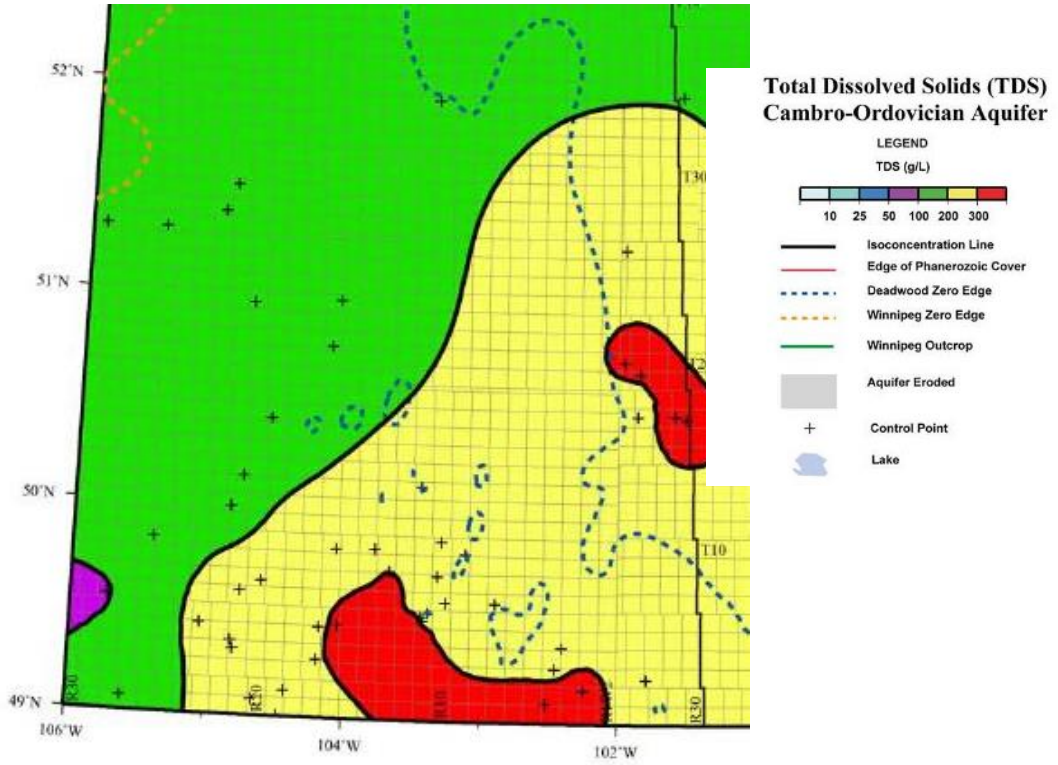
Expanding Storage

Site Selection and Characterization

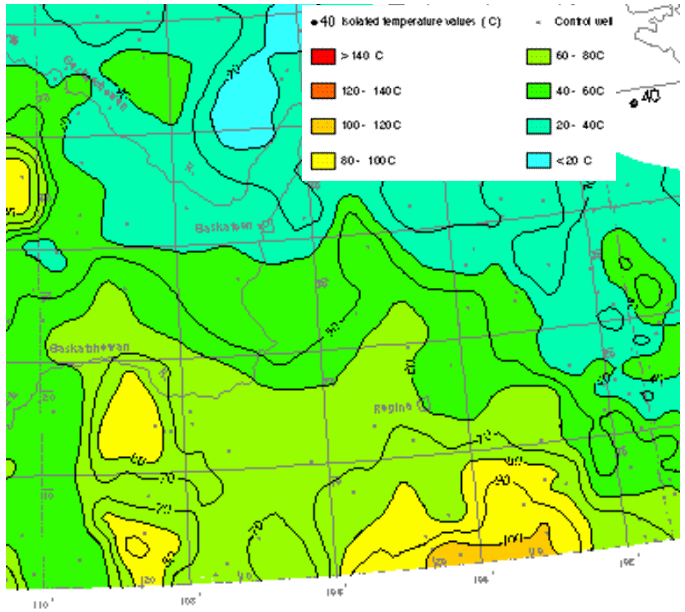


Kreis et al, 2004

Uncertain Stratigraphy



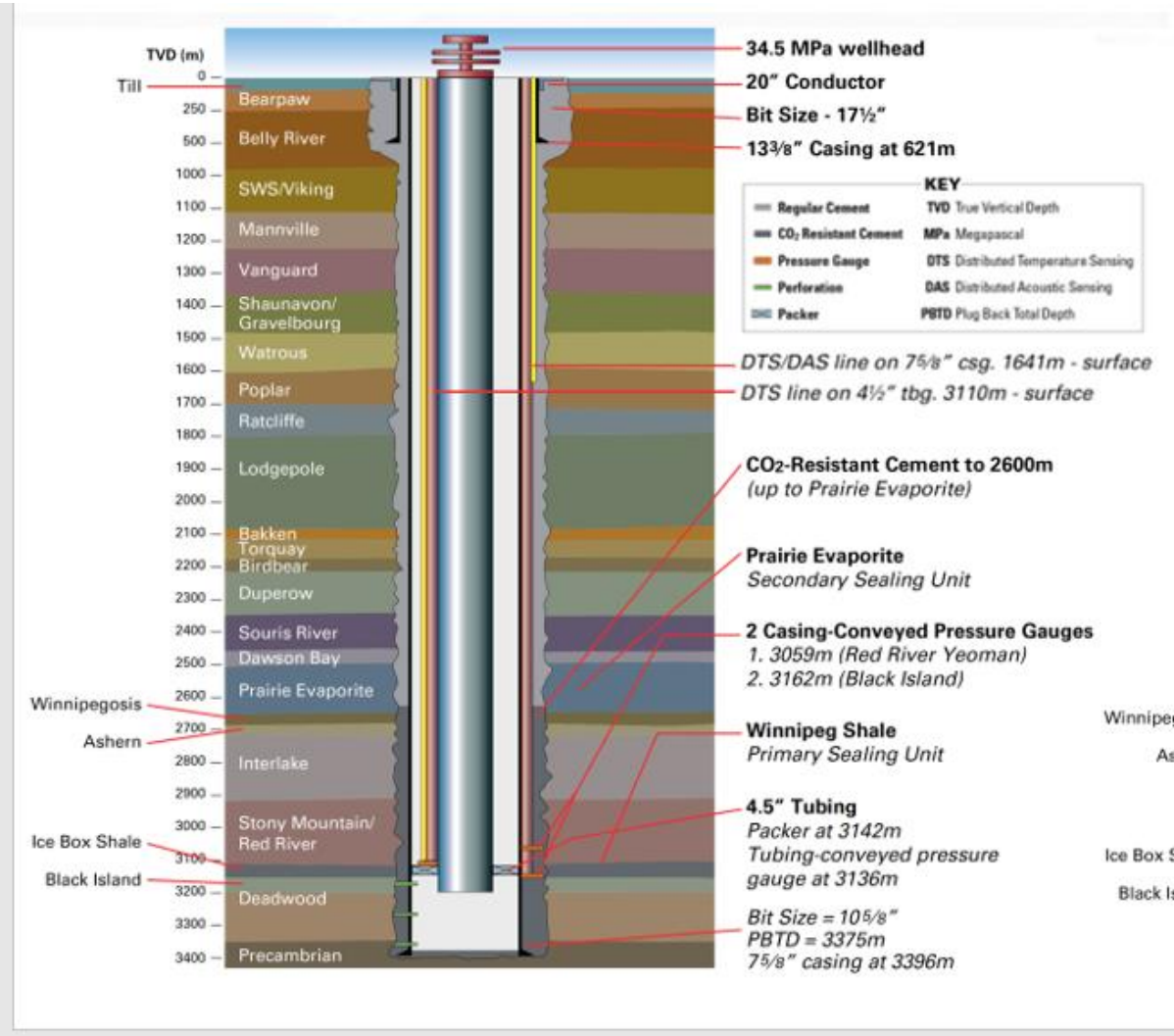
Very Salty
300,000ppm (30%)+



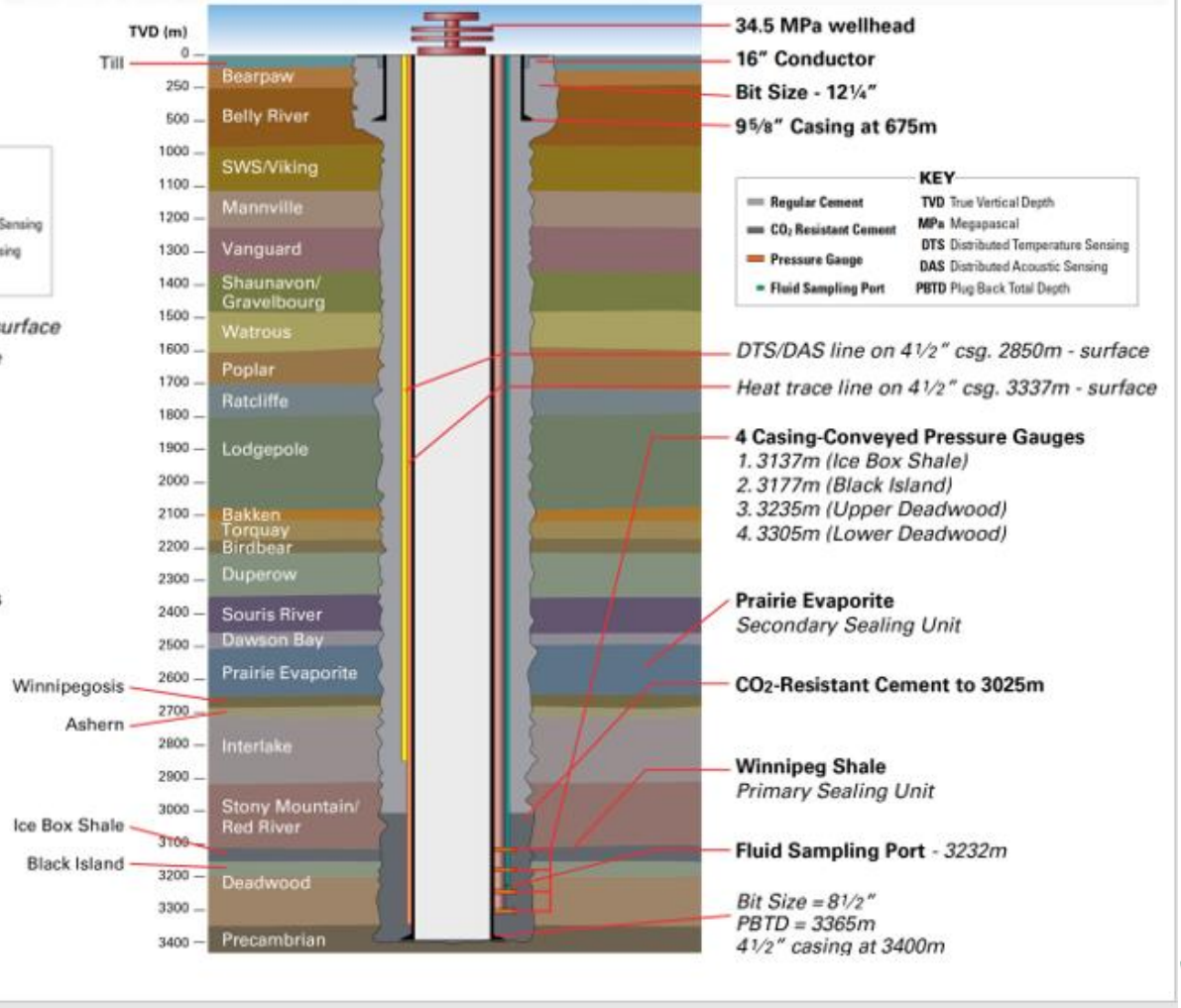
Very Hot!
120C+

Well Design

PTRC INJ
5-6-2-8W2M



PTRC OBS
D5-6-2-8W2M

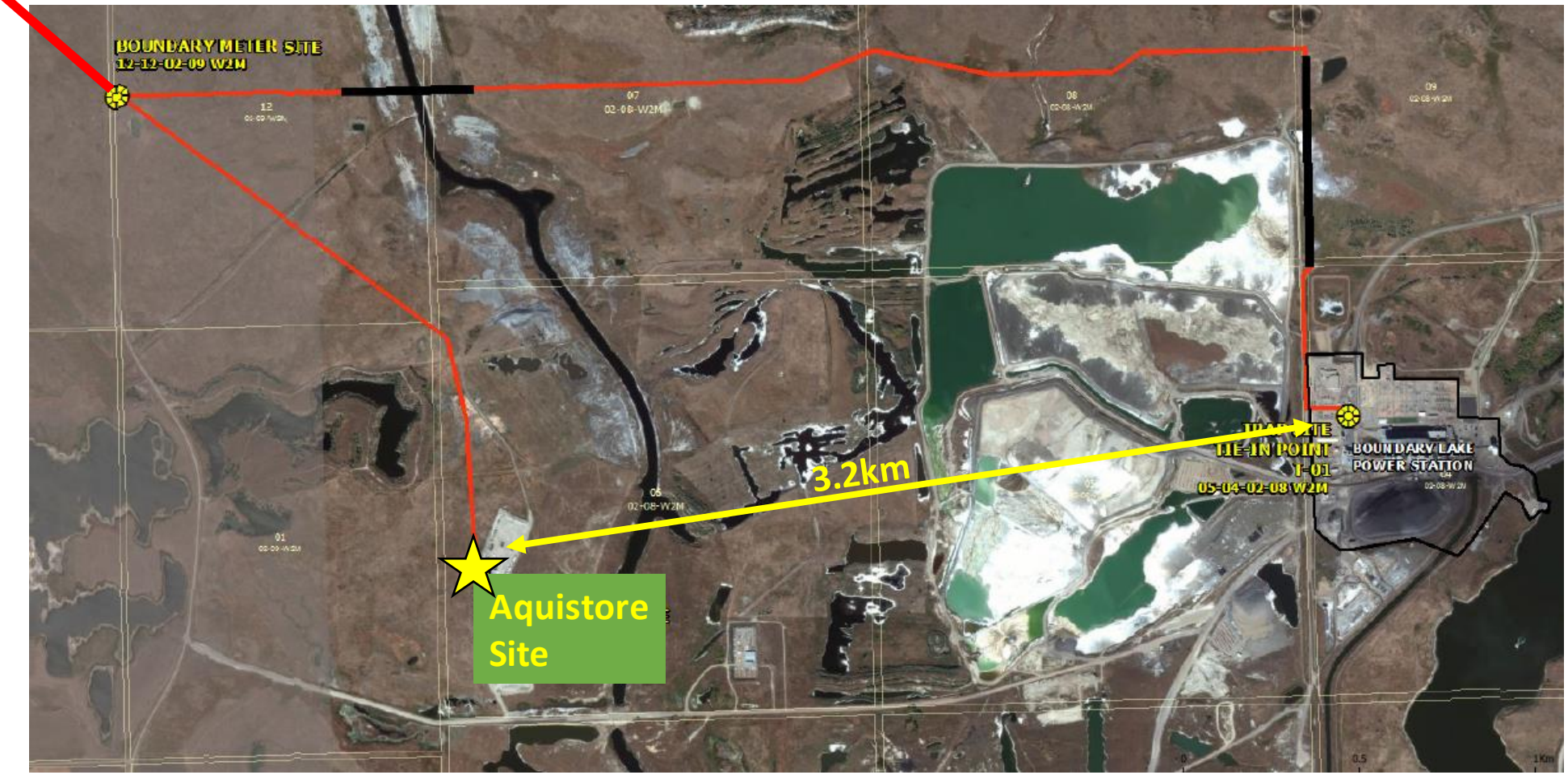


Injection parameters

- Bottom Hole Pressure Measured at 3136m
  - 90% Fracture at this depth = 6,020 psig (41,000kPa)
  - ESDV Trip Point = 6,020 psig
  - PCV-907 also has an override that starts to limit the maximum it can open at 5,920 psig
- Annulus surface pressure
  - ESDV Trip Point = 1,000 psig
- Alarms built into DCS for Surface Casing and Ambient CO_2 Levels.
- Data is reviewed on a monthly basis, although monitored in real time

Pipeline Route

Sales to Whitecap (Weyburn)



Objective of a Monitoring Program

Measurement – **M**onitoring – **V**erification (MMV)

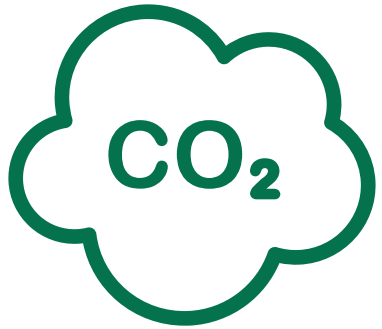
01 Demonstrate containment and conformance of injected CO_2

02 Manages risks identified by the project's risk management plan

03 Collect data needed to verify and update models and simulations

04 Enable the potential transfer for long-term liability

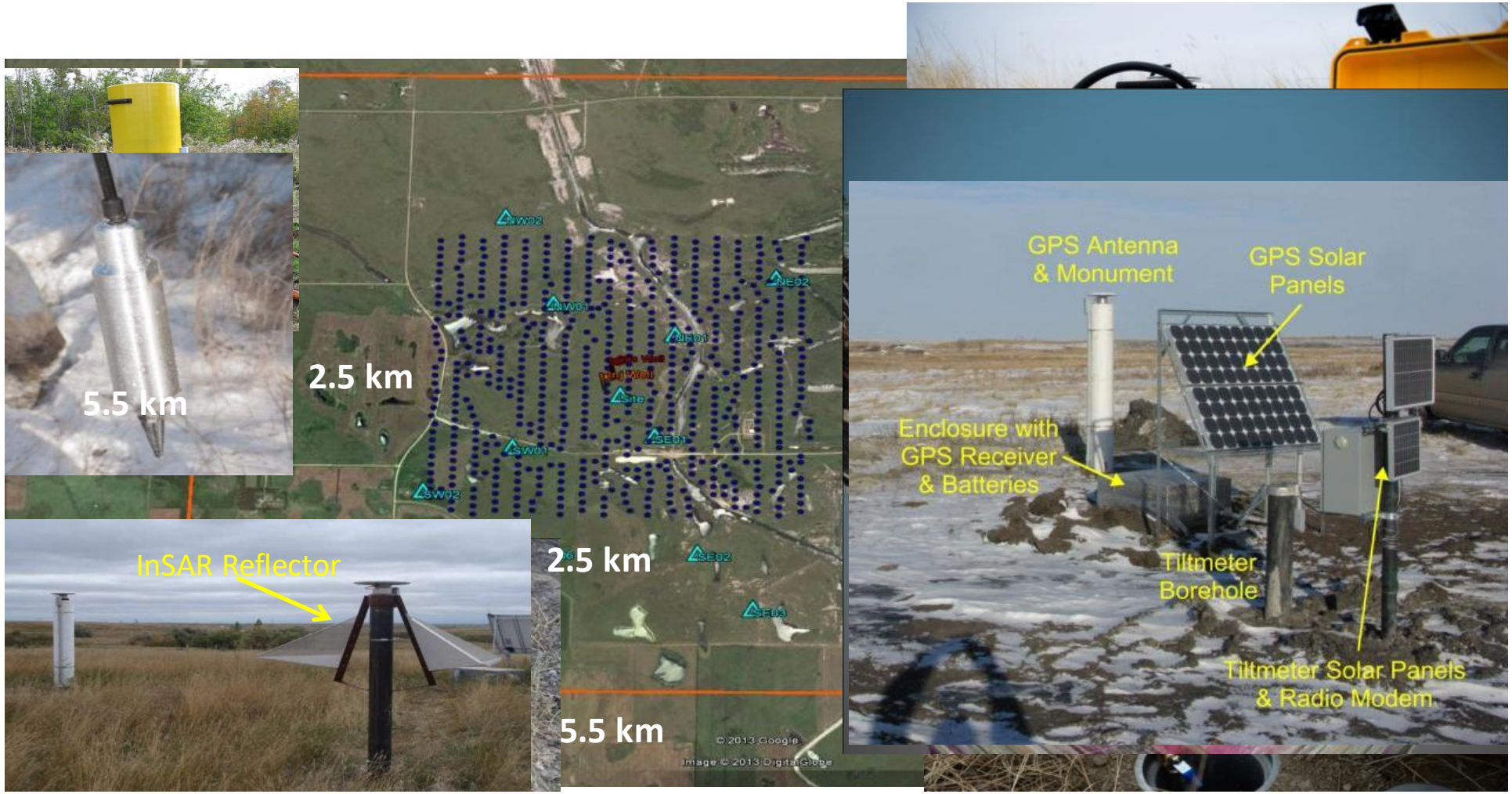
05 Meet any regulatory requirements that are set out in legislation



510 K

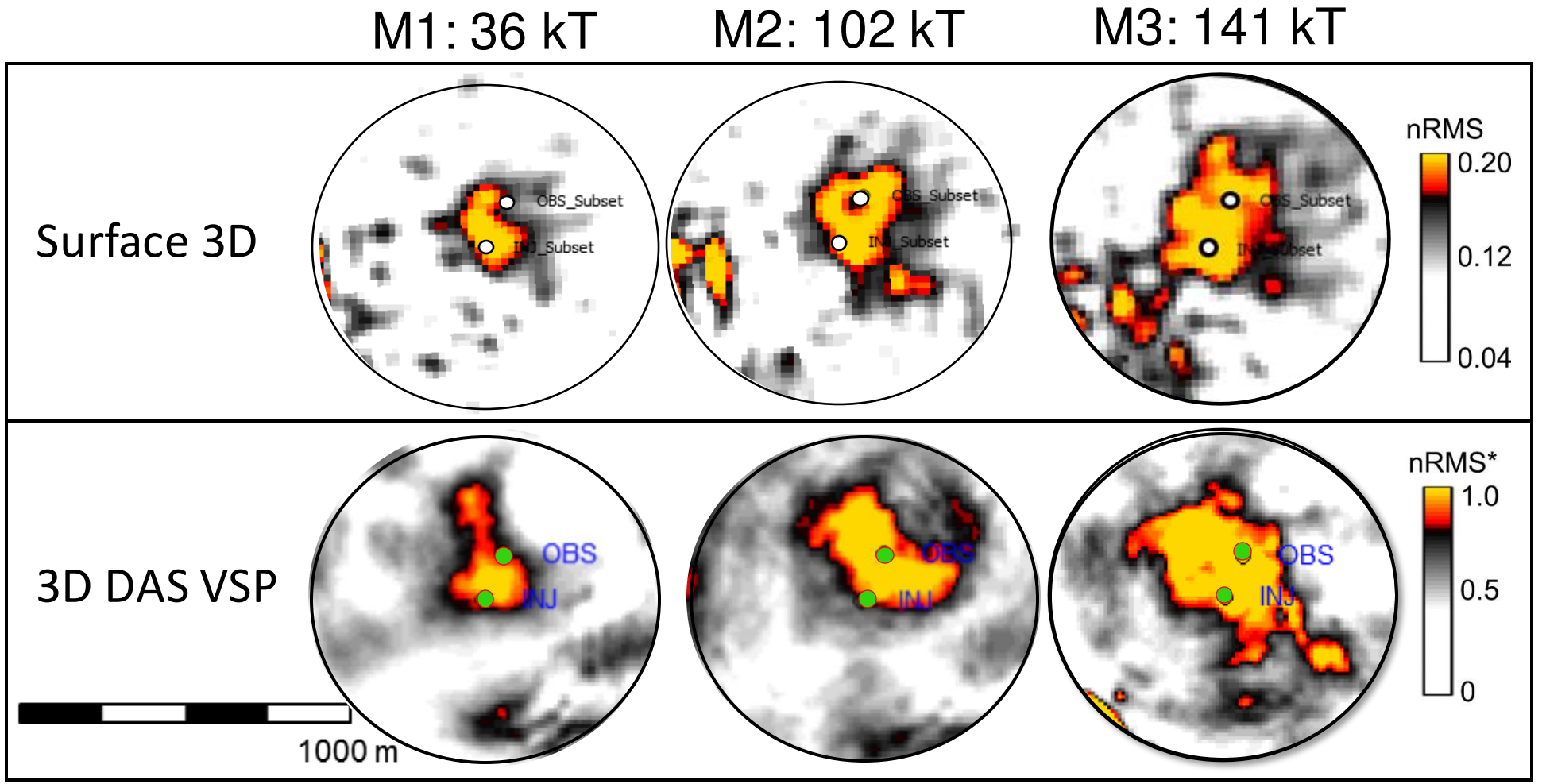
tonnes of CO_2 stored at Aquistore

Aquistore Monitoring Program



What it looks like

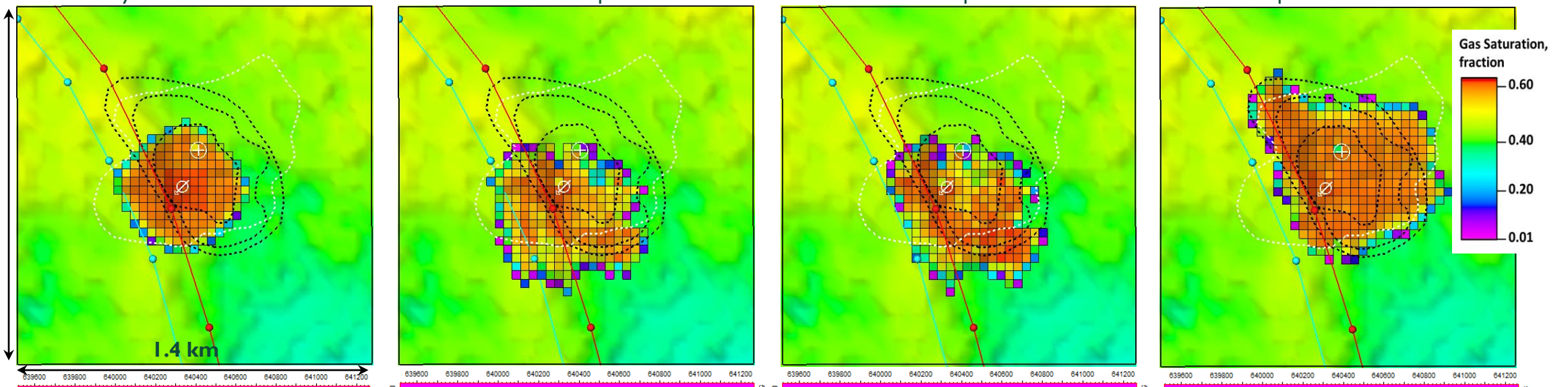
Seismic Studies Surface Geophones vs. DAS



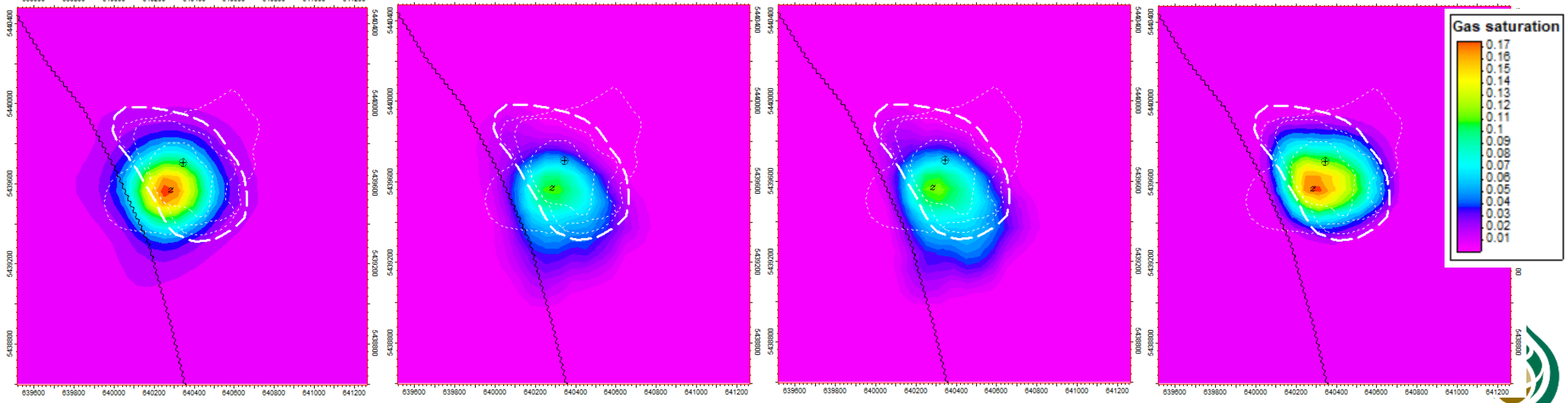
Different History Matched Realizations of CO2 Plume

Layer Cake Model | with Stochastic Properties | with Stochastic Properties + Flexure | Stochastic Properties + Flexure + Seismic

Simulated CO2 Saturation
Deadwood D – Top Layer Only



Saturation-Thickness Average
Map – All Layers



The PTRC and CCUS

- Weyburn and Aquistore Projects
- Turning CO2 EOR into Storage
- Generate **H**ighly **Q**ualified **P**eople at our universities
- PTRC is an organization that can sit between government, industry and academia, and work towards mutually beneficial solutions
- This is a growing industry in the country – The PTRC remains at the forefront

Progressive Aboriginal RELATIONS COMMITTED

Canadian Council for Aboriginal Business

Thank you!