Petroleum Technology Research Centre

A Decade of CCUS and Associated Research at the Weyburn and Midale Oilfields, Saskatchewan, Canada

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September 2012

Presentation to US Energy Agency, Washington DC

IEAGHG
WEYBURN-MIDALE
CO_2 MONITORING
AND STORAGE PROJECT

Petroleum Technology Research Centre

- ***Non-Profit Research & Development***
- ***Collaborative partnership with Industry, Government and Research Organizations***
- ***Committed to reducing environmental impacts of oil production***
  - **STEPS (EOR Centre of Excellence)**
- ***Research associated with CO_2 management***
  - **IEAGHG Weyburn –Midale CO_2 Monitoring & Storage Project**
  - **Aquistore**

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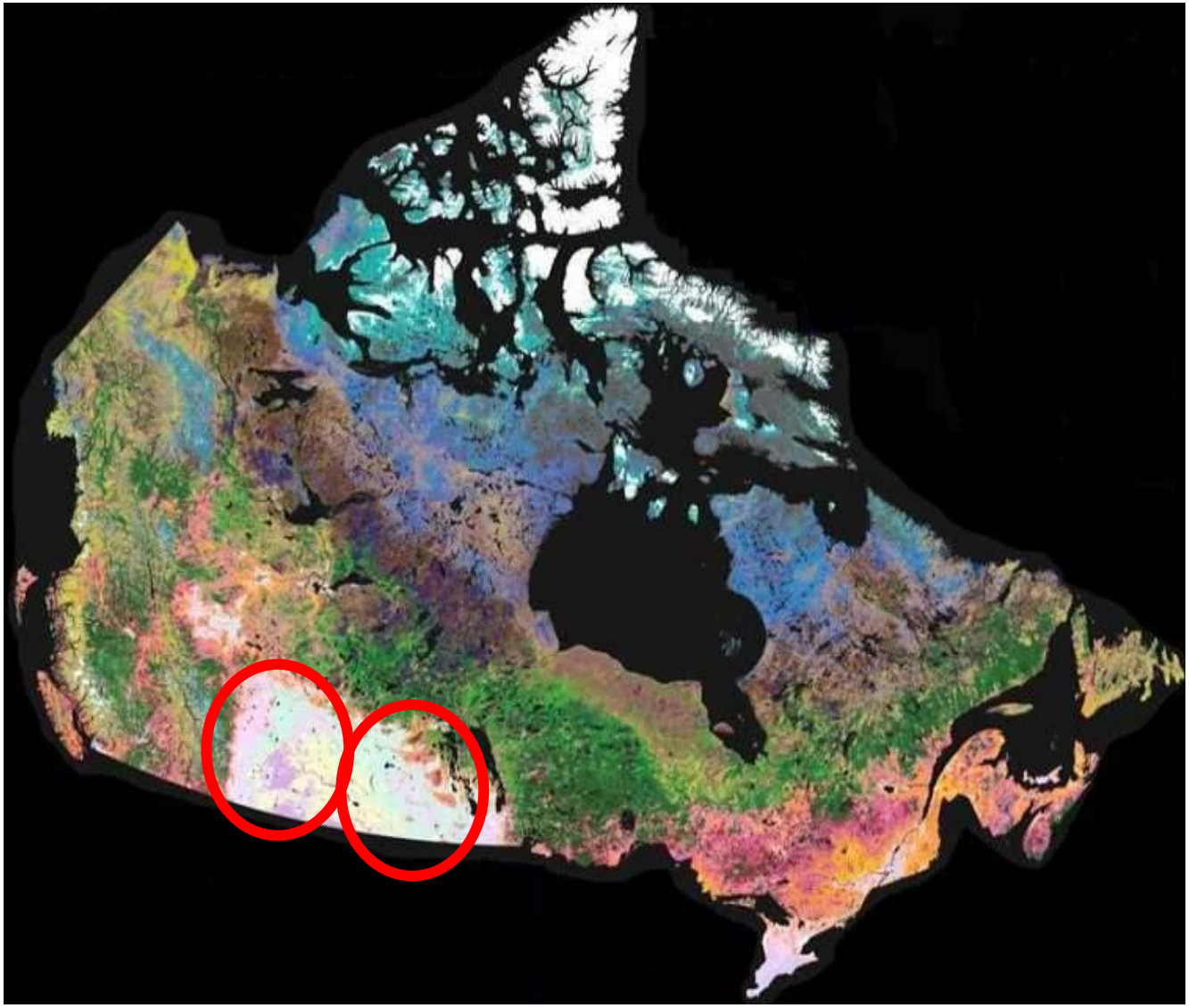
Main Areas of Current CCUS Development in Canada



Current Government Funding of CCS Projects: Alberta and Saskatchewan

Project	Federal	Provincial
Quest Project	120 MM	745MM
Swan Hills	----	285 MM
Enhance (ACTL)	63 MM	495MM
Boundary Dam	240MM	
Aquistore	14 MM*	5 MM
Weyburn-Midale	+15 MM**	3.5 MM

* 5 million from Sustainable Development Technology Canada (stand-alone federally funded agency) and 9 milliion ECOeti

**Includes NRCan and USDOE (Canada and USA)

IEAGHG Weyburn-Midale CO_2 Monitoring & Storage Project (WMP) 2000 to 2012

Commercial EOR operations in Weyburn and Midale oilfields utilise anthropogenic CO_2

Over 20Mt of CO_2 injected and stored since 2000

WMP has used these sites to study technical aspects of CO_2 geological storage

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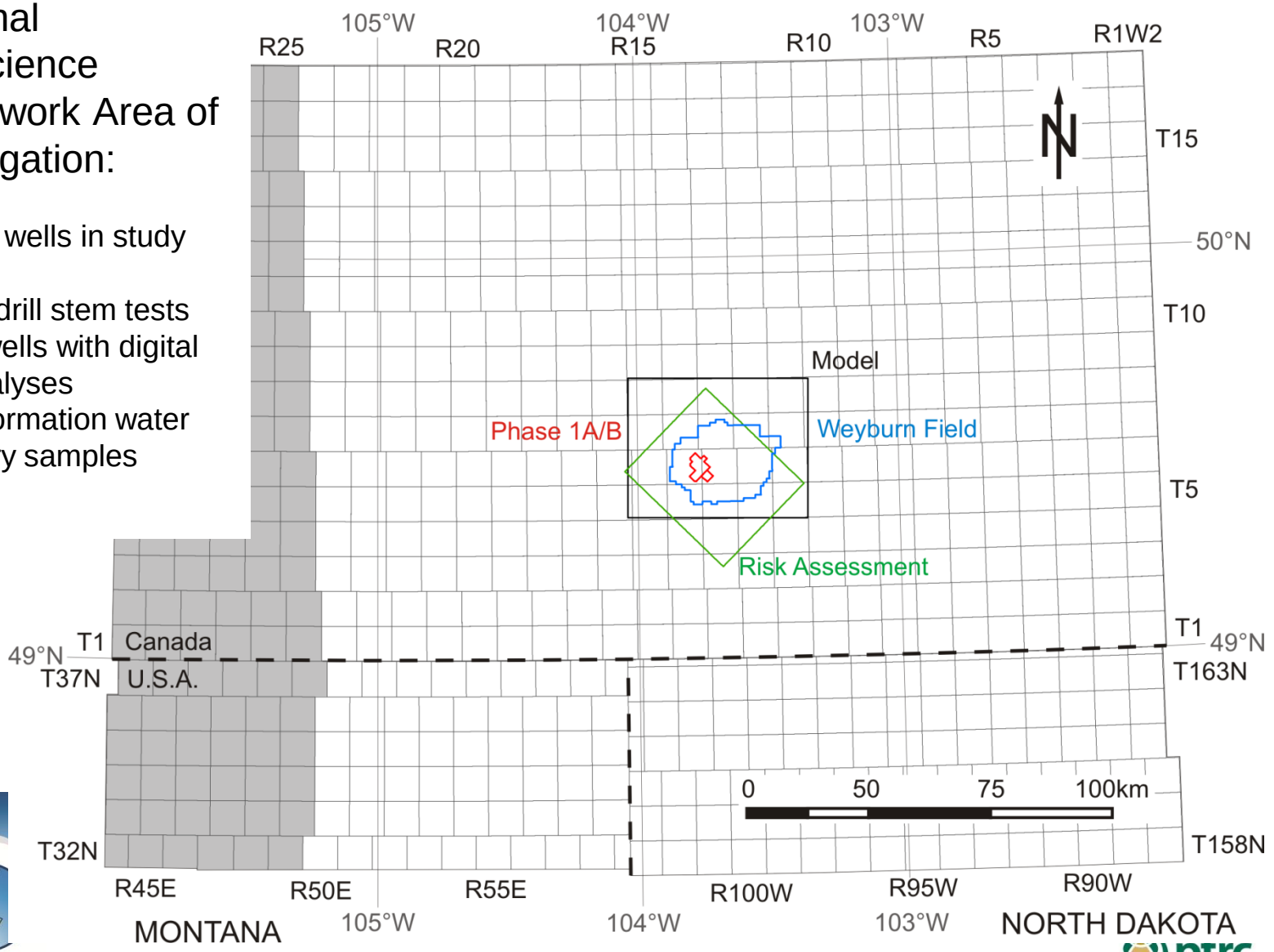
Staged Study Areas:

Regional GeoScience Framework Area of Investigation:

>30,000 wells in study area
-11,121 drill stem tests
-6,292 wells with digital core analyses
-9,207 formation water chemistry samples



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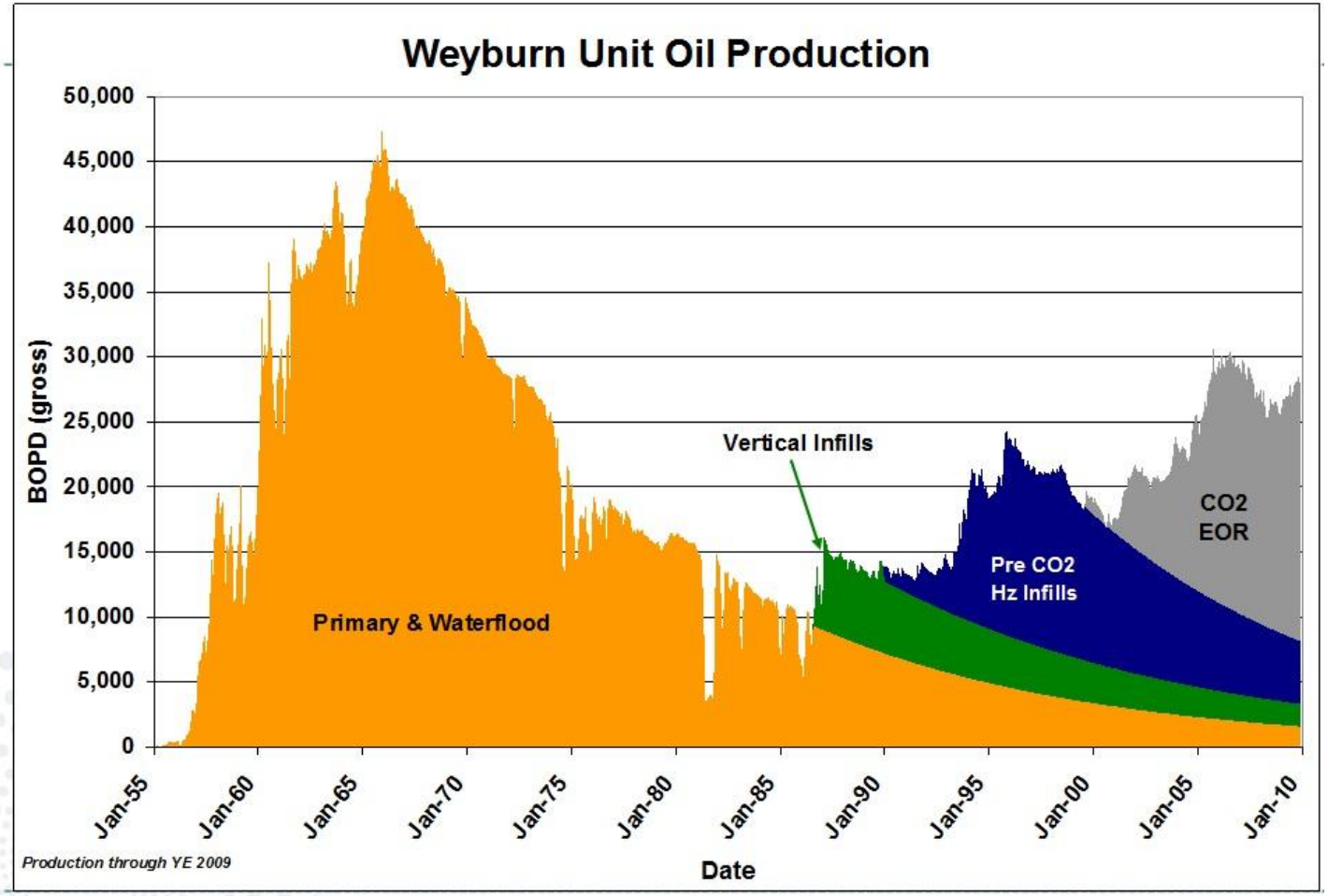

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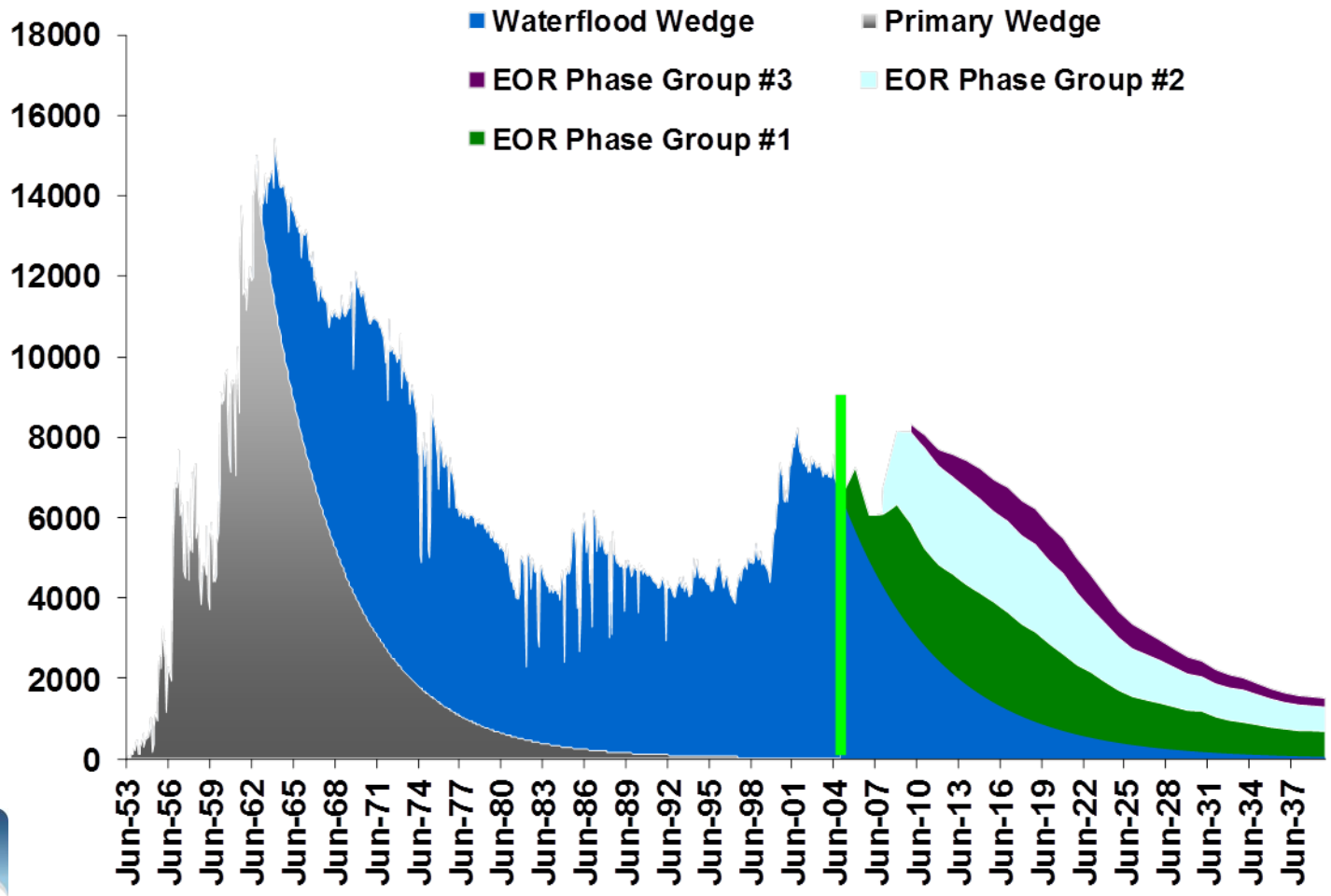
Midale Field CO2-EOR



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Best Practice Manual

Introduction

- Purpose, scope, context, background, …

Characterization

- Regional geology
- Regional hydrogeology
- Containment characterization
- Geomechanical characterization
- Geochemical characterization

Performance predictions

- CO_2 migration
- Capacity and mass partitioning
- Containment

Geochemical monitoring

- Groundwater
- Soil gas
- Reservoir fluids
- Reservoir/caprock core

Geophysical monitoring

- Geophysical char. of rock-fluid system
- Feasibility studies
- Downhole monitoring methods
- 3D seismic methods

HM and performance validation

- Prediction/measurement comparison
- Revision of Geologic Models

Well integrity

- Integrity assessment
- Design considerations
- Remediation and conversion
- Abandonment considerations
- Integrity monitoring and field testing

Risk assessment

Community outreach

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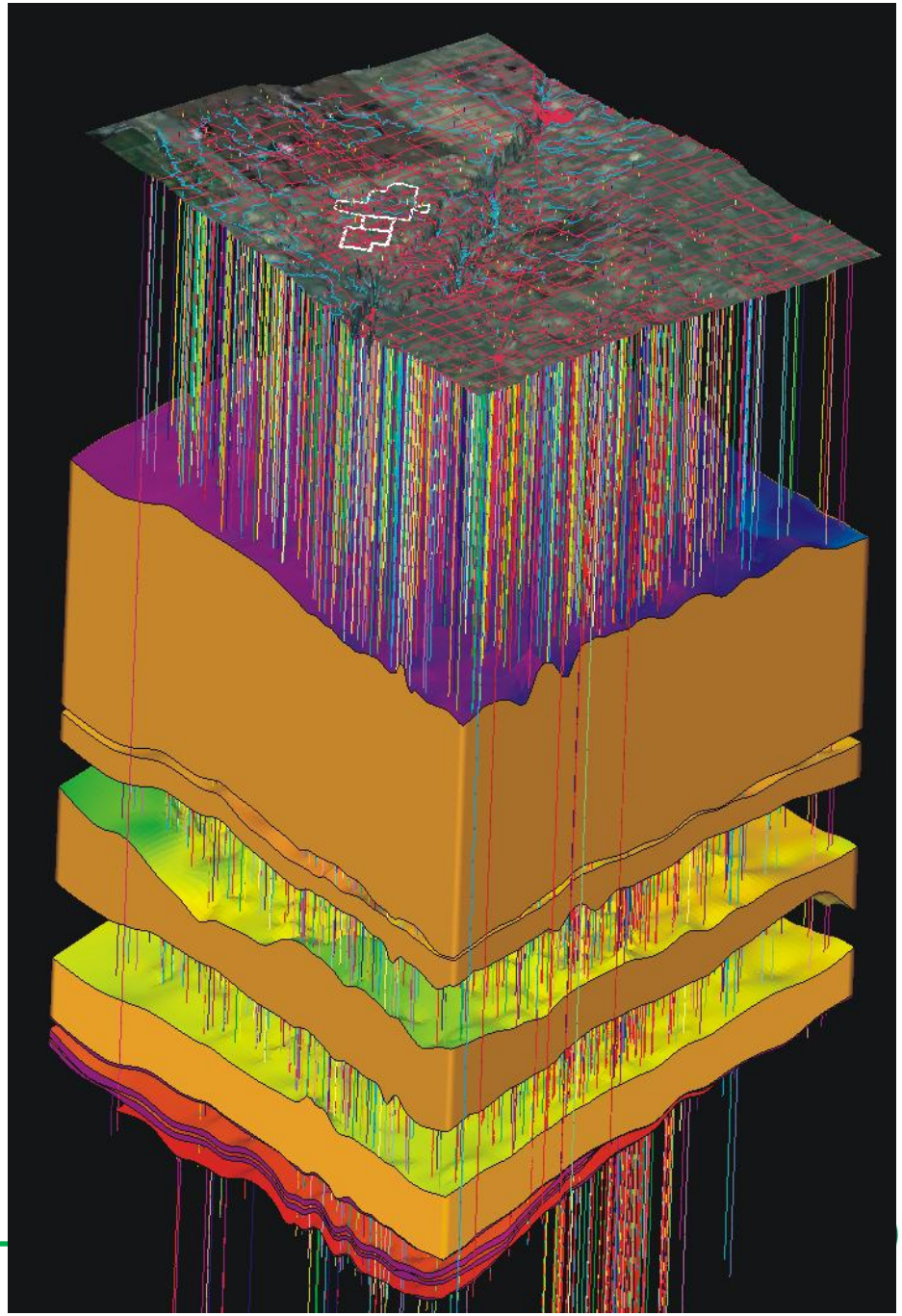
Revised Model

Was improved with:

1. More detailed aquitard characterization
2. Larger area
3. More accurate subcrop mapping
4. Increased well density (800 in area)



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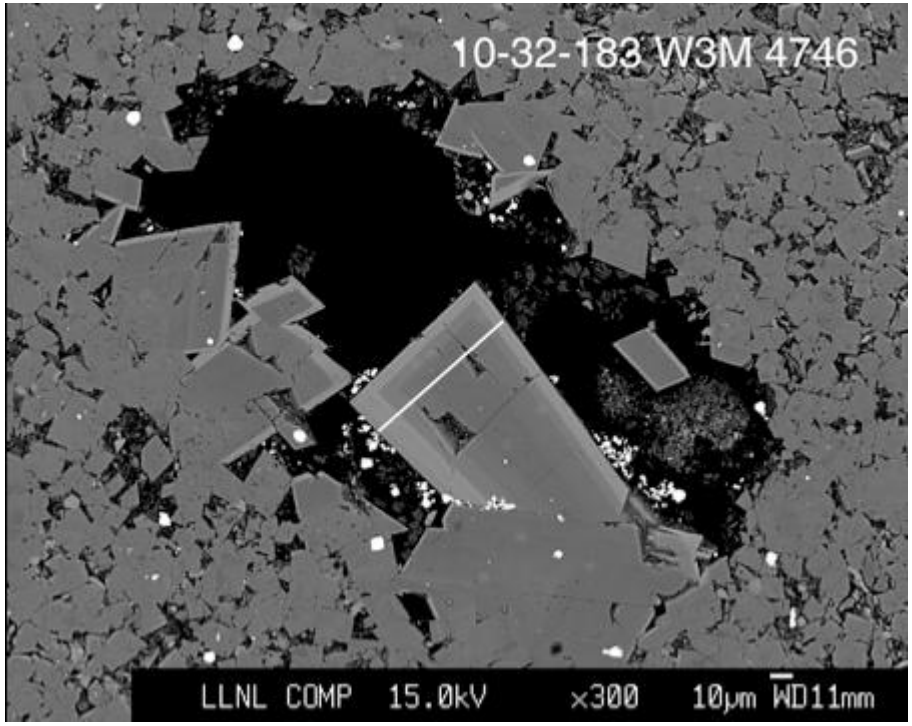
Natural Analogue Study



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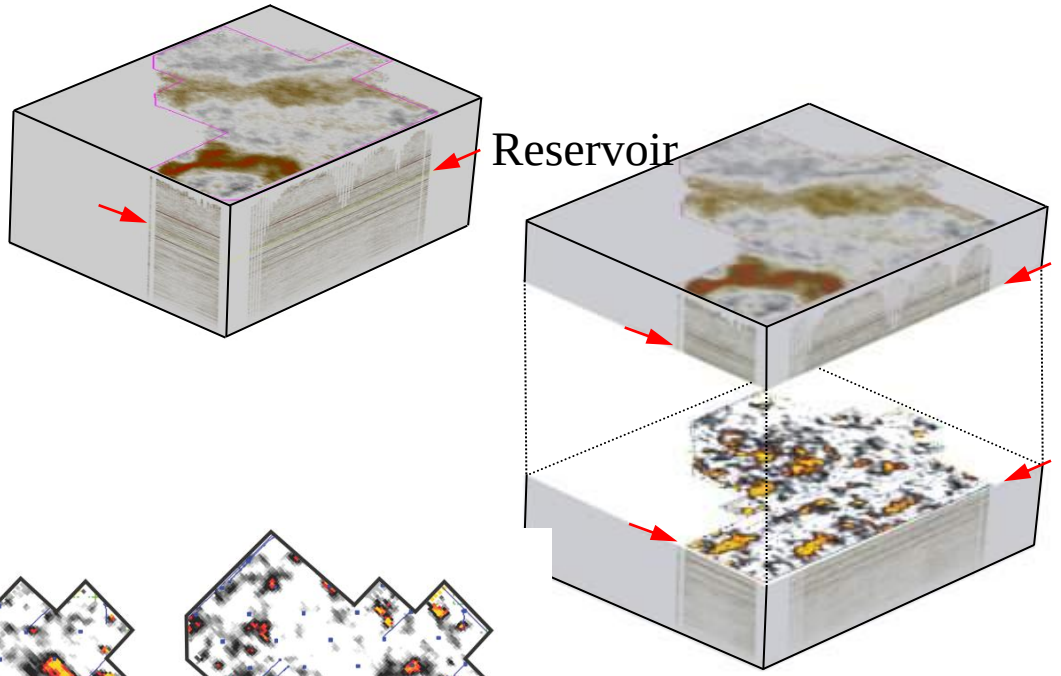
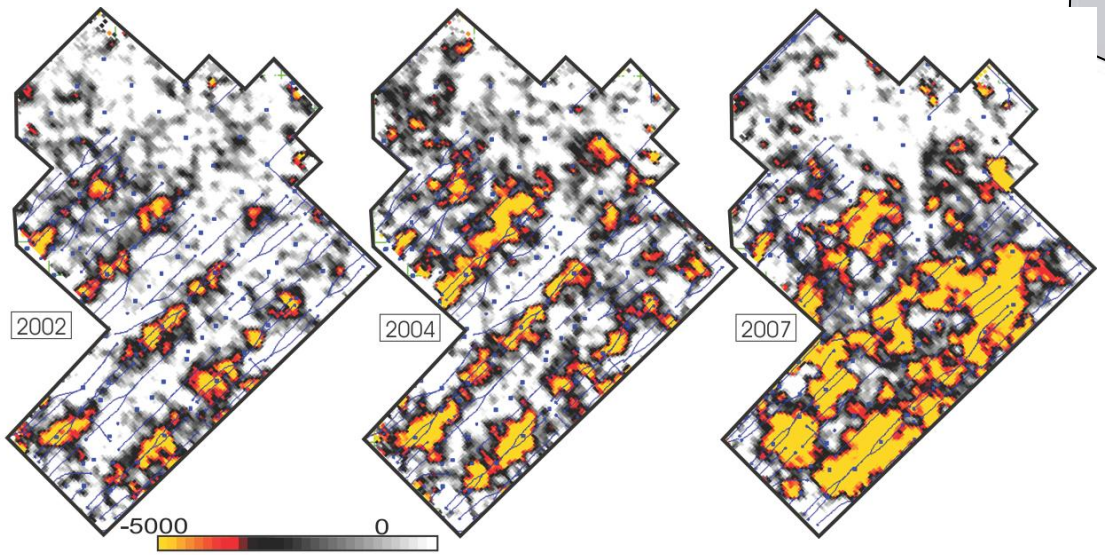
3D Time-Lapse Seismic: CO_2 Distribution

Monitoring regional subsurface distribution of CO_2:

- *Verifying storage conformance*
- *A primary input for updating reservoir models*
- *Optimal resolving capability*
- *Sensitive to low CO_2 saturations*
- *Data repeatability is fundamental*





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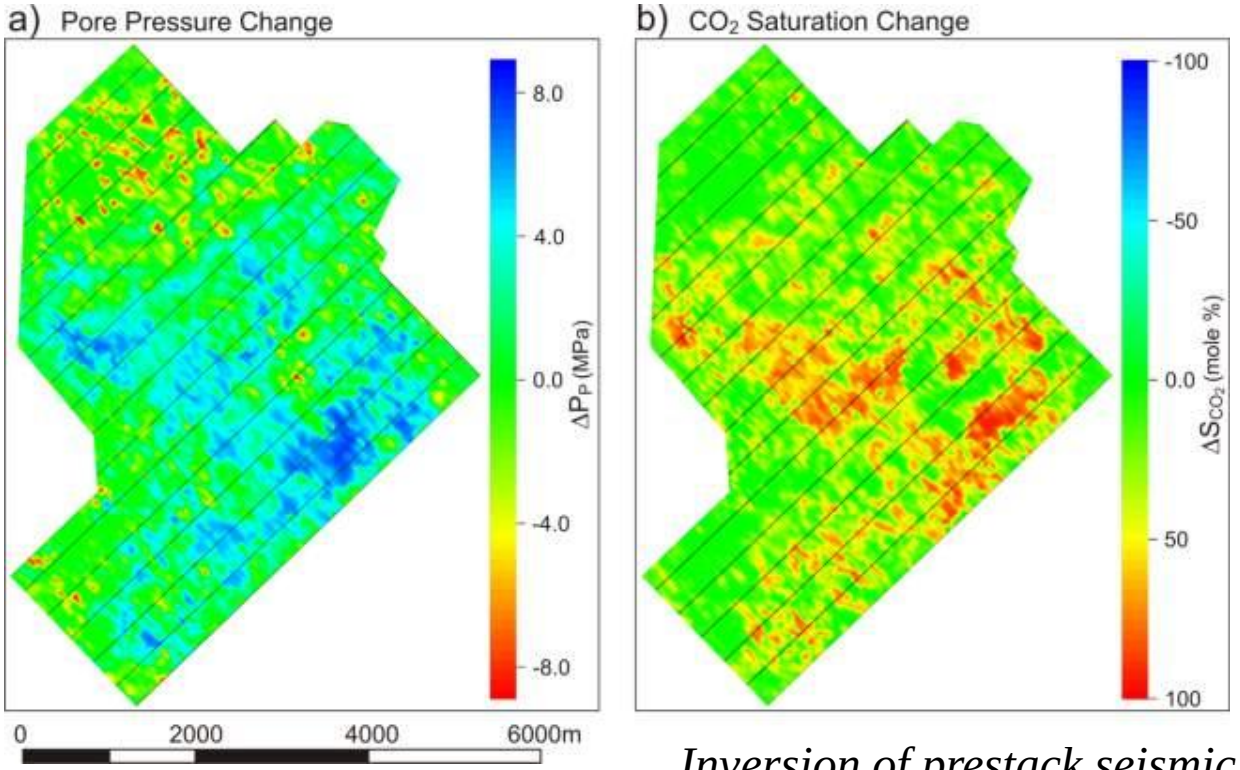
3D Time-Lapse Seismic: Pressure vs. CO_2 Saturation



Inversion of prestack seismic data:

- *Semi-quantitative CO_2 saturation and P changes*
- *Results are model-based*
- *Characterization of reservoir rock physics is essential*
- *Monitoring survey design is important as "long offset" data are required*

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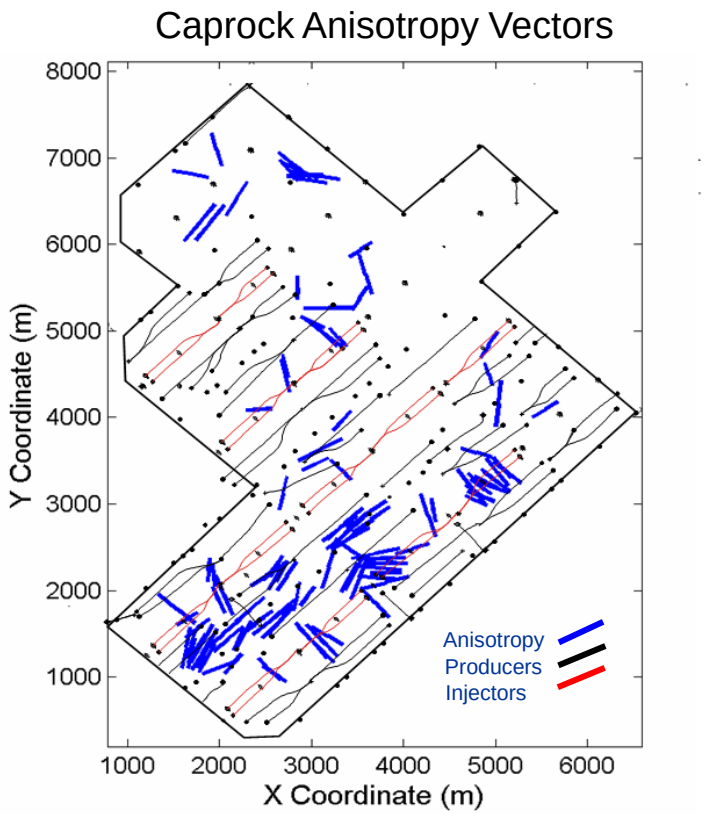
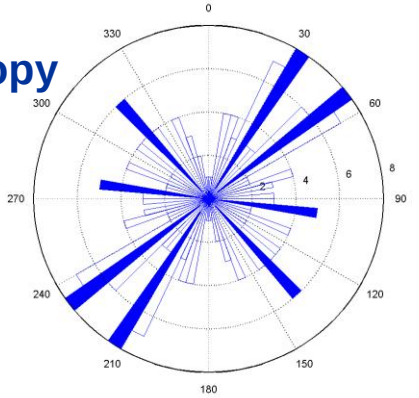
Seal Integrity: Fracture Mapping

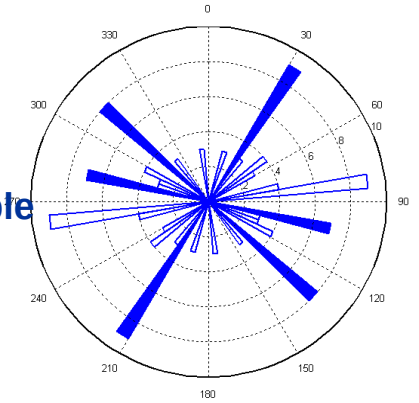


Anisotropy vectors



Bunge, 2000

Reservoir oriented core sample fracture analysis



Seismic anisotropy as a proxy for vertical fracturing:

- *Means of identifying potential fracture zones regionally*
- *Scale of individual fractures and hydraulic conductivity is not resolved*
- *"Fracture zones" may warrant subsequent attention*

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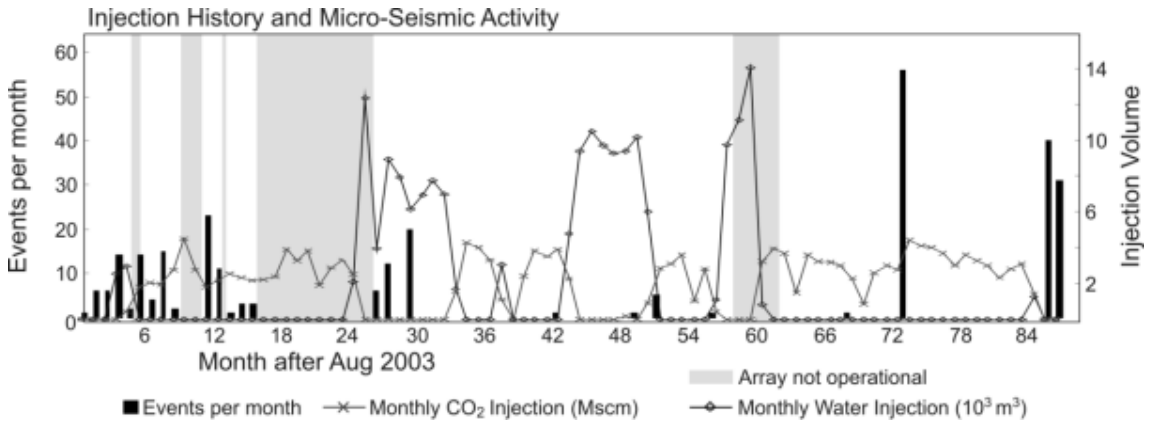
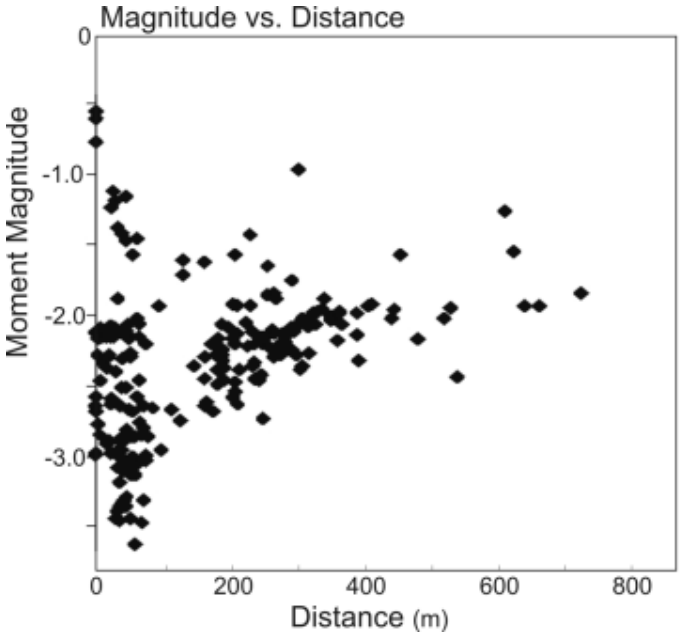
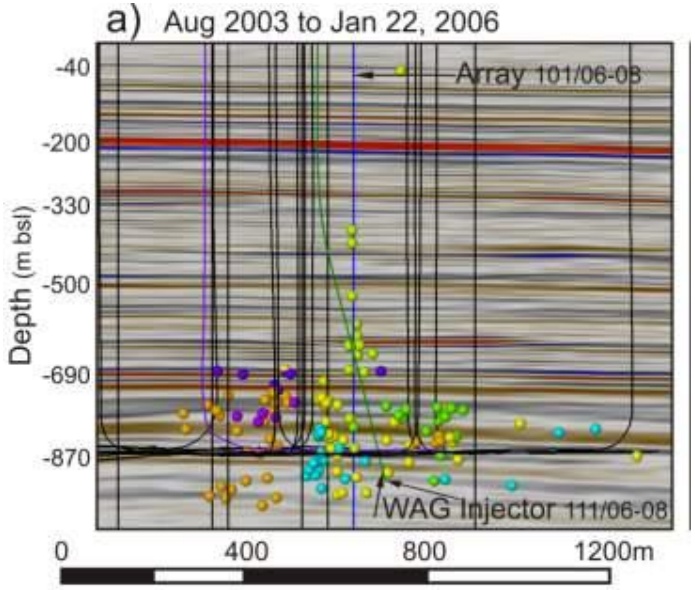
Passive Seismic Monitoring

Documentation of time, magnitude and location of seismicity:

- *Public assurance*
- *Integrity of the sealing units*
- *Injection control*







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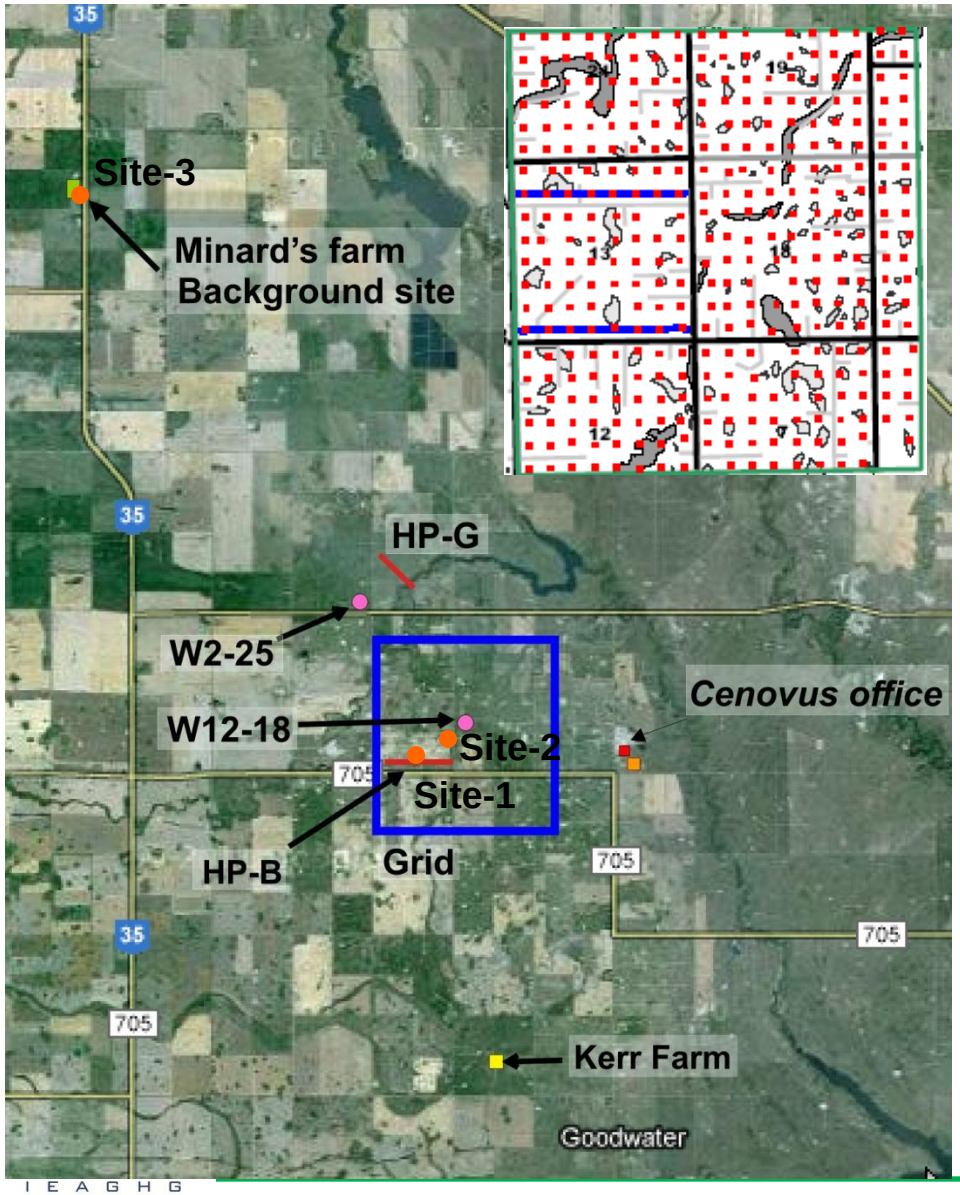
Soil gas monitoring: Overview



Research Providers

- ✓ Dave Jones et al. (BGS)
- ✓ Dave Risk et al. (StFX)

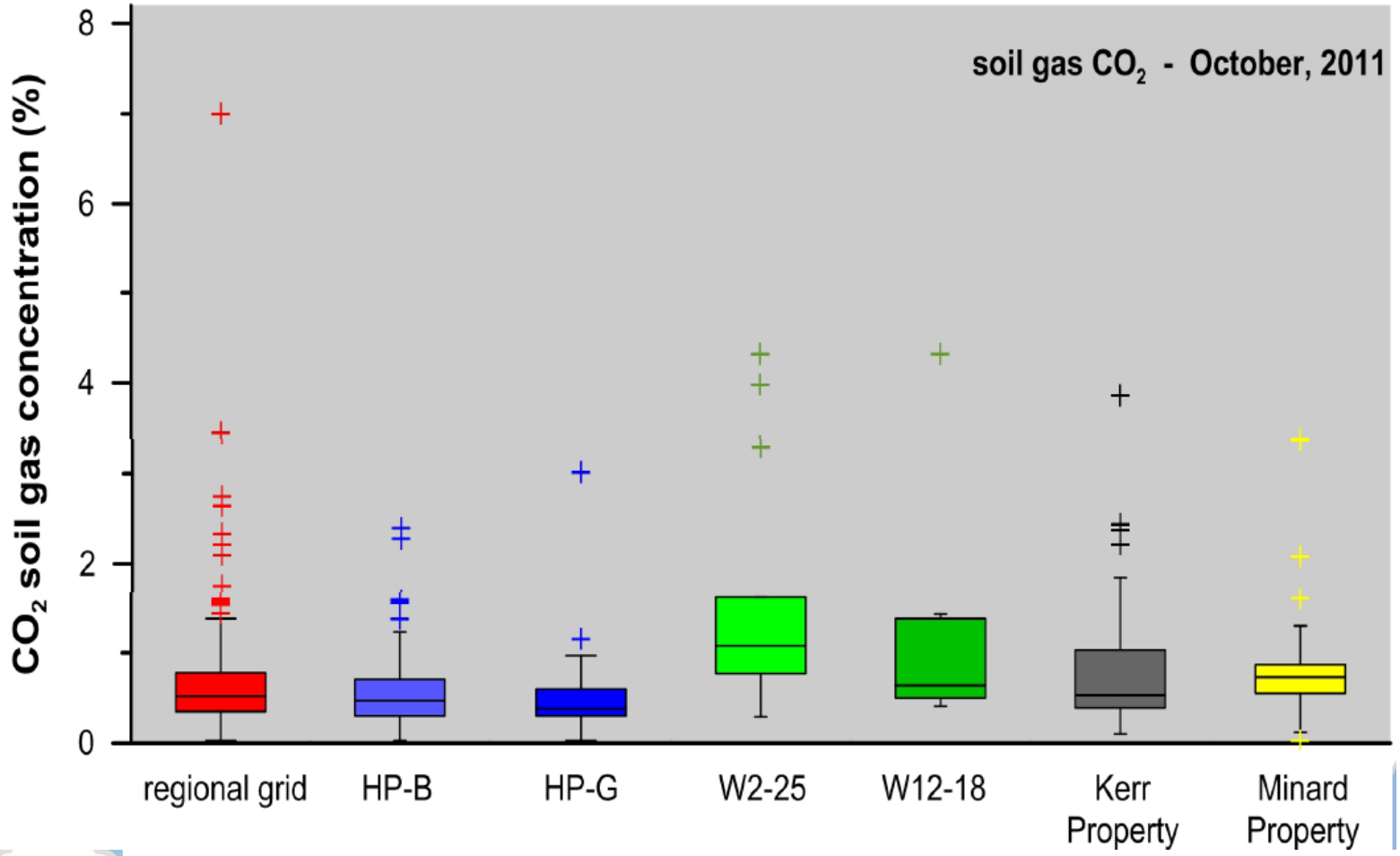
Measurements

- ✓ CO_2, O_2, N_2 conc.
- ✓ CH_4, C_2H_6, C_2H_4 conc.
- ✓ Rn, He conc.
- ✓ CO_2 flux
- ✓ C isotopes

Methods

- ✓ Single-depth (BGS), depth-profile (StFX) CO_2
- ✓ CO_2 flux (BGS)
- ✓ Continuous CO_2 (BGS), CO_2 flux (StFX)
- ✓ $\delta^{13}CO_2$, $^{14}CO_2$

Soil Gas Monitoring Data



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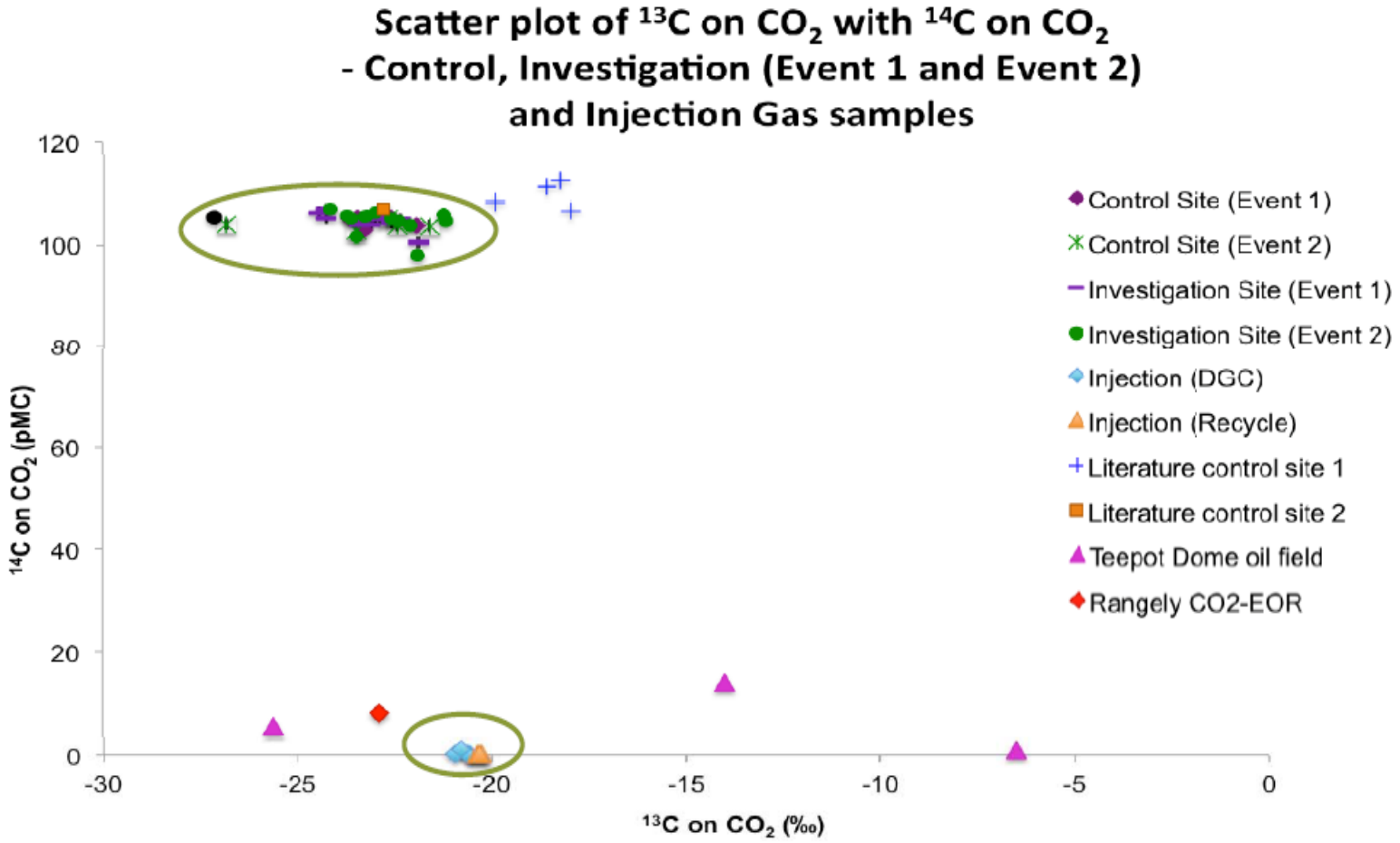
Carbon Isotopes



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Well Integrity: Field Testing Program

Modified coring tool:
→ Direct confirmation of cement

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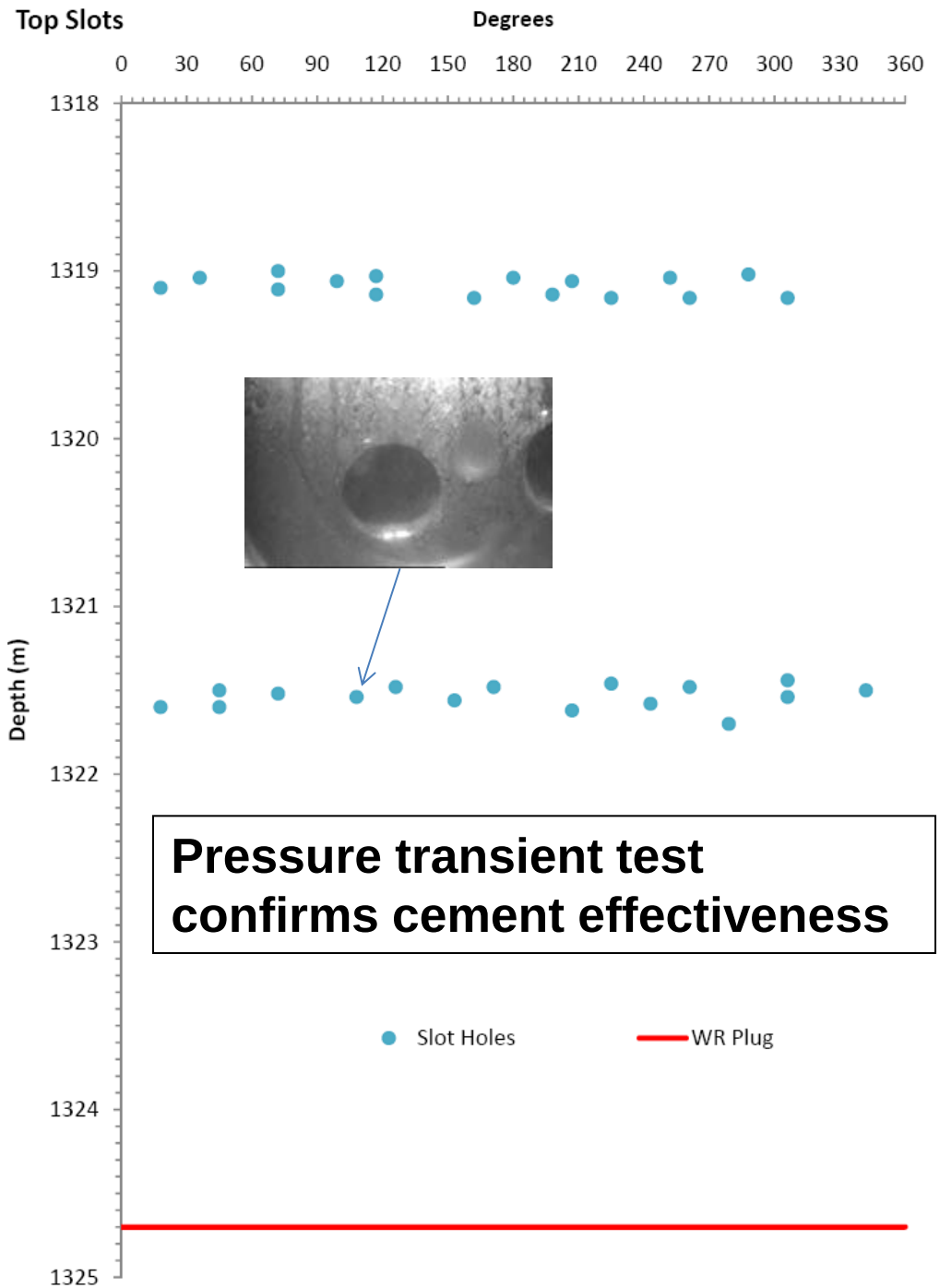
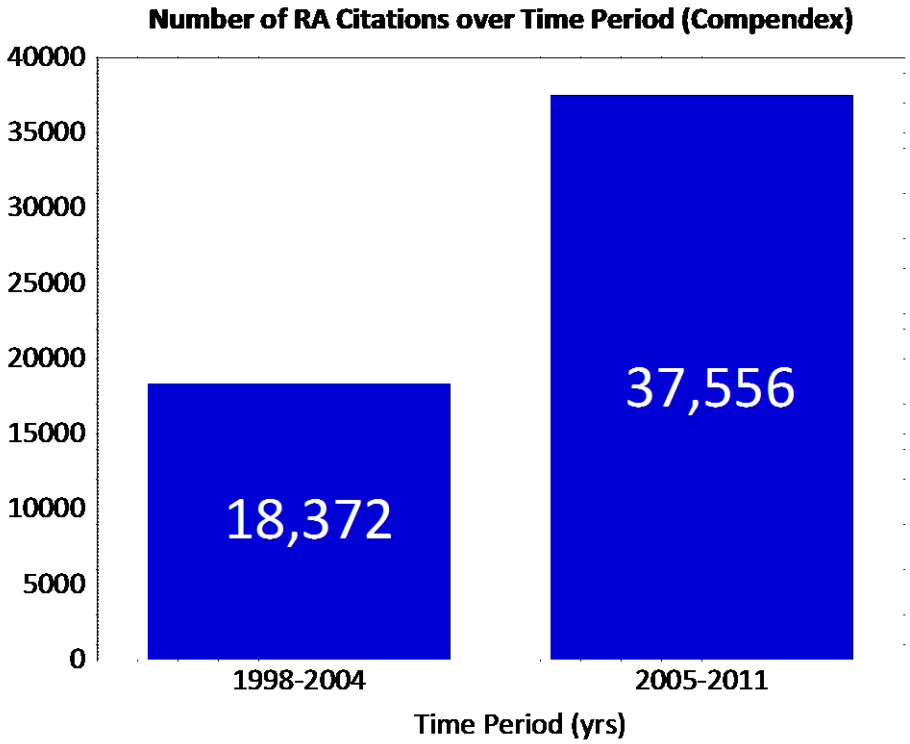
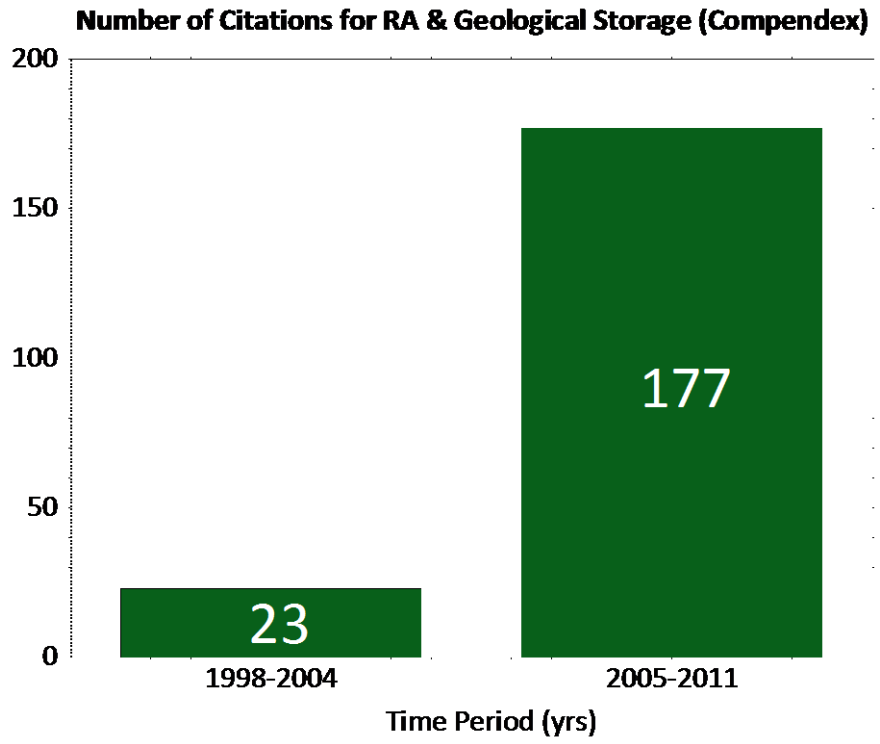


Field Testing Program

RA and Geological Storage of CO_2





104% Increase ***670% Increase***

And for just the final? year of each Phase:
2004 – 4 and 2011 – 57

1,325% Increase

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Process: Geosphere & Biosphere Risk

Technical Inputs
- Wellbore integrity research
- Characterisation of reservoir characteristics & transport of CO_2
- Seismicity of area
- Characterisation of CO_2 reactions in reservoir
- Monitoring techniques & effectiveness

Geosphere Risk Assessment

Outputs
- CO_2 risk events (initiating event & pathway) & ranking
- Mass of CO_2 released if event occurs
- Likelihood of each event occurring & releasing CO_2

Stakeholder Engagement

Stakeholder Values

Building Capacity to Engage

Biosphere Risk Assessment

Other Technical Inputs
- Characterisation of aquifers
- Characterisation of surface water
- Characterisation of soils / sediments
- Behaviour of CO_2 in soils, sediments, groundwater, surface water
- Receptors in environment
- Toxicology (animal, plant, human)

Outputs
- Risks to biosphere assets (ranking & severity)

Acceptability of Risks

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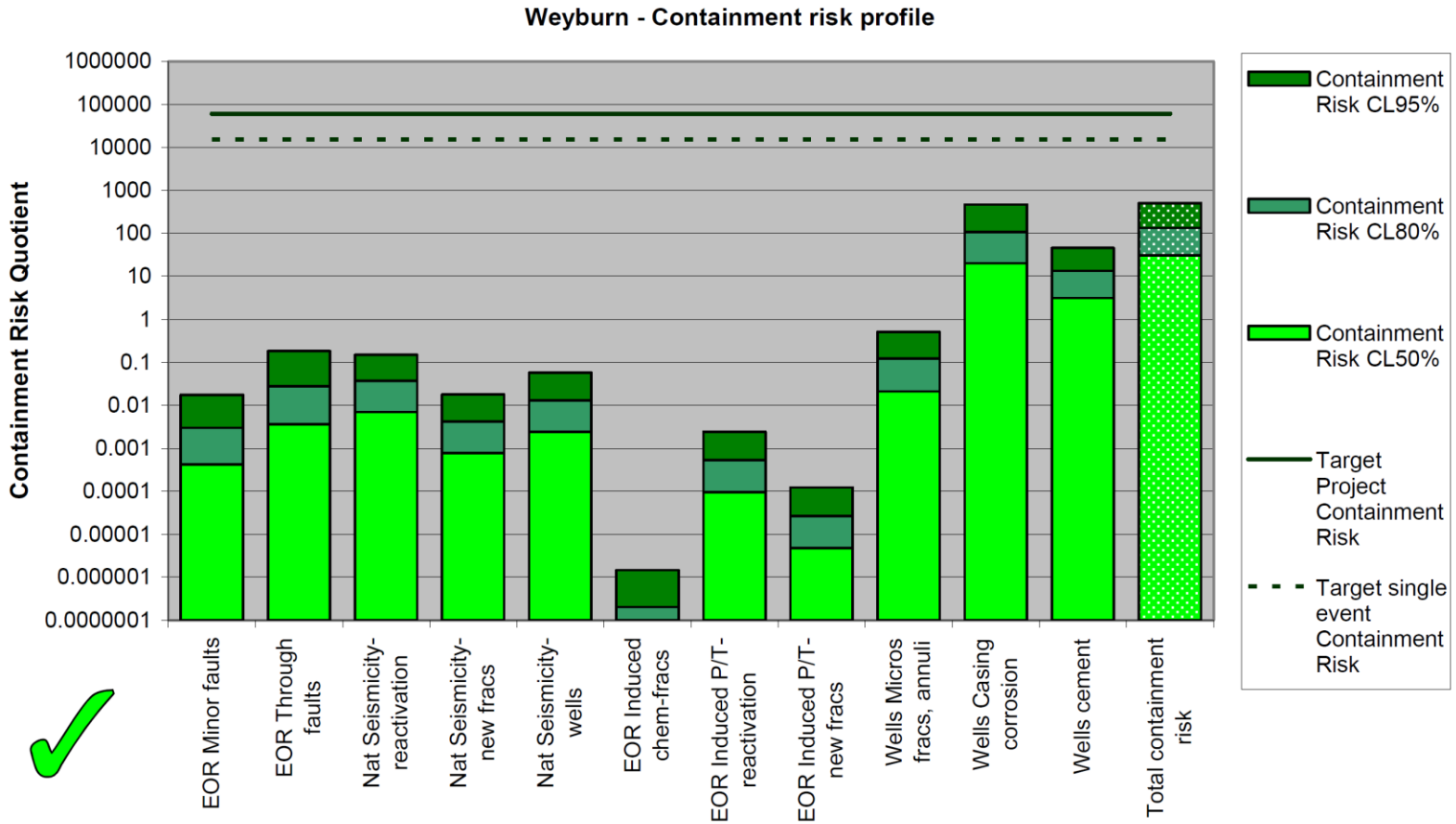
Mitigation Measures

Containment Risk Profile

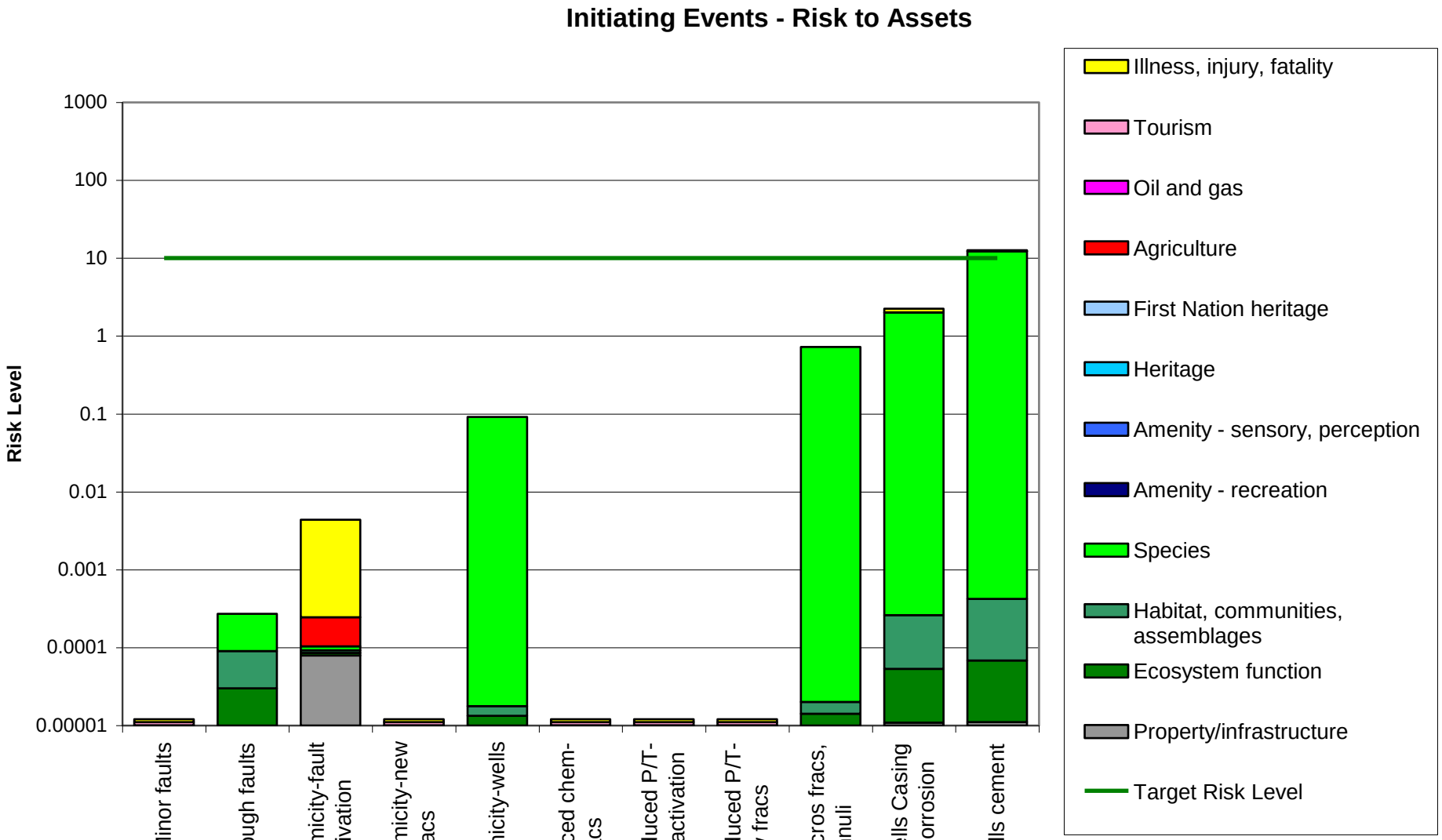
The storage will retain most of the CO_2 injected

Containment risk assessment



No further work would be required to demonstrate containment acceptability.

Identifying Biosphere Assets Most At Risk From Pathways



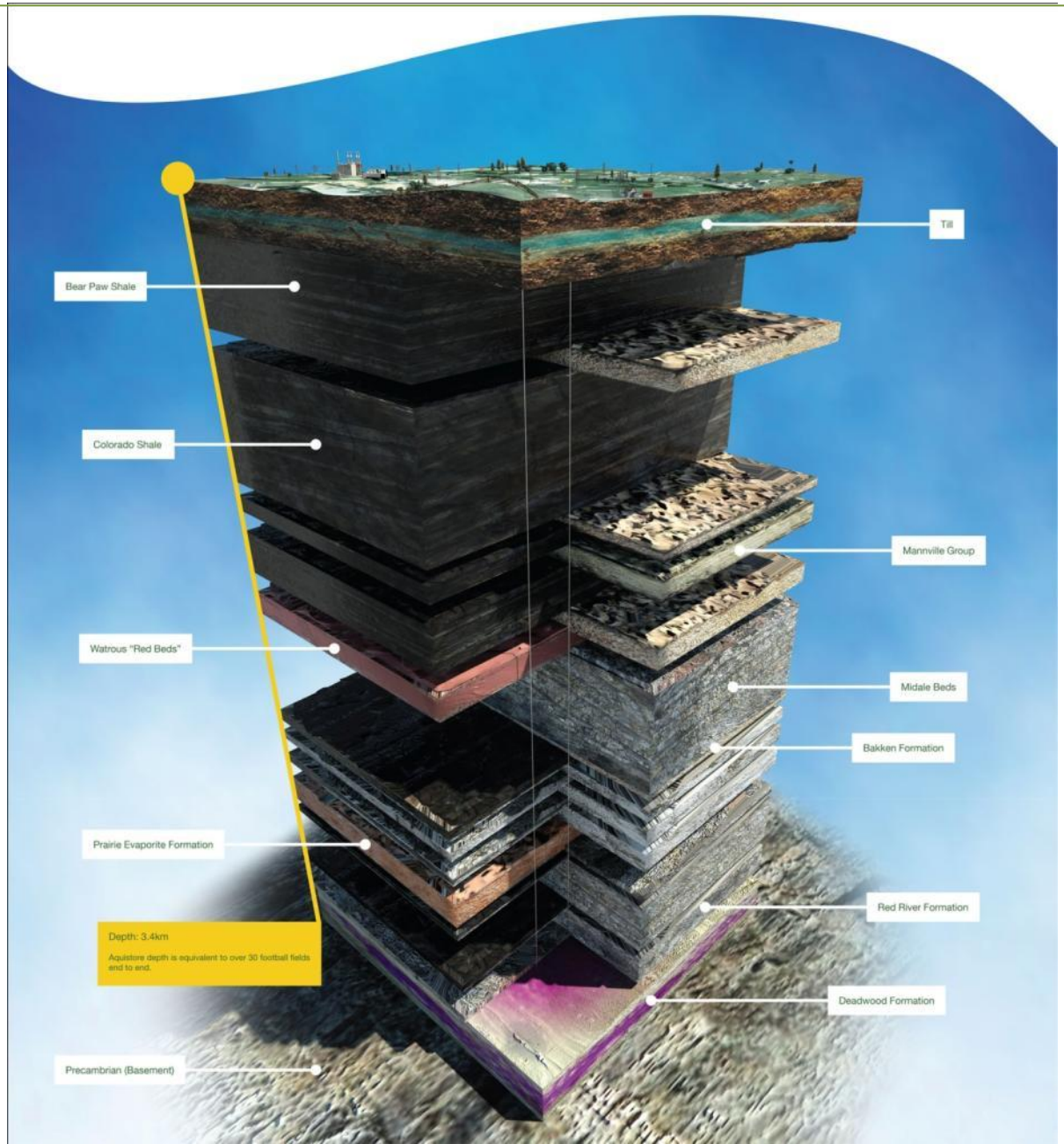
Boundary Dam Near Estevan Saskatchewan

PTRC Aquistore Project Location

Ground level view towards Boundary Dam Power Station with drilling rig in foreground

Well location remains largely free of water during the 1:500 year flood in Saskatchewan 2011

Subsurface Model



Thanks for your attention

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