

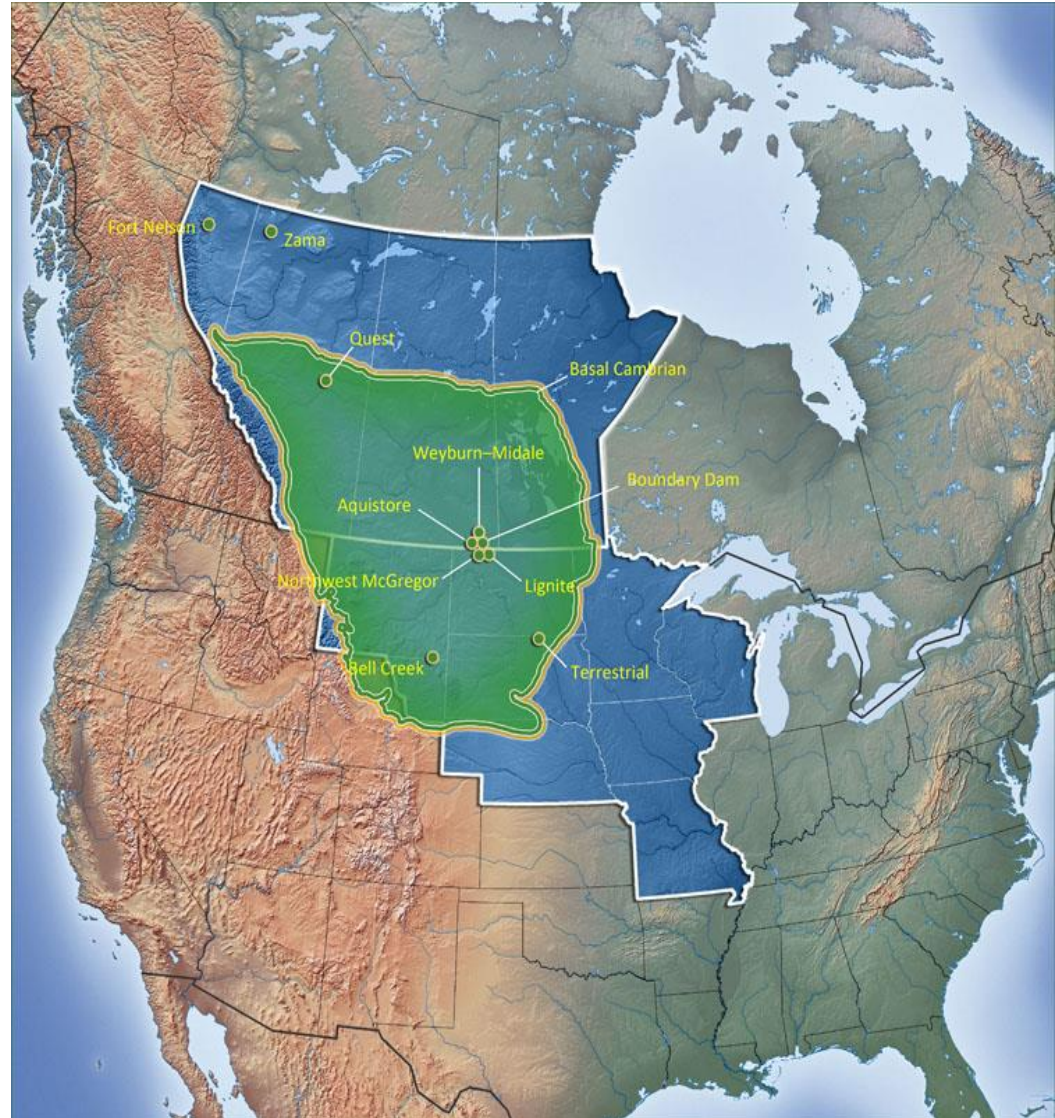
# AQUISTORE



**Kyle Worth, P.Eng, PMP**  
**Aquistore Project Manager**  
**Petroleum Technology Research Centre**



- **Non-Profit Research & Development Company**
- **Collaborative partnership with Industry, Government and Research Organizations**
- **Extensive network of researchers worldwide**
- **Research associated with CO<sub>2</sub> management**
  - **IEAGHG Weyburn –Midale CO<sub>2</sub> Monitoring & Storage Project**
  - **SaskCO<sub>2</sub>USER**
  - **Aquistore**





- Integrated CO<sub>2</sub>-EOR and CO<sub>2</sub> Storage CCUS Project
- Practical application of observations, new data, and evidence is key
- Moving beyond pilot demonstration to commercially operating scale
  - Risk Assessment
  - Uncertainties
  - MMV



# AQUISTORE: DEEP SALINE CO<sub>2</sub> STORAGE PROJECT



  
**107,000**  
CUMULATIVE TONNES  
OF CO<sub>2</sub> STORED 

 **0**  
INDUCED SEISMIC  
EVENTS



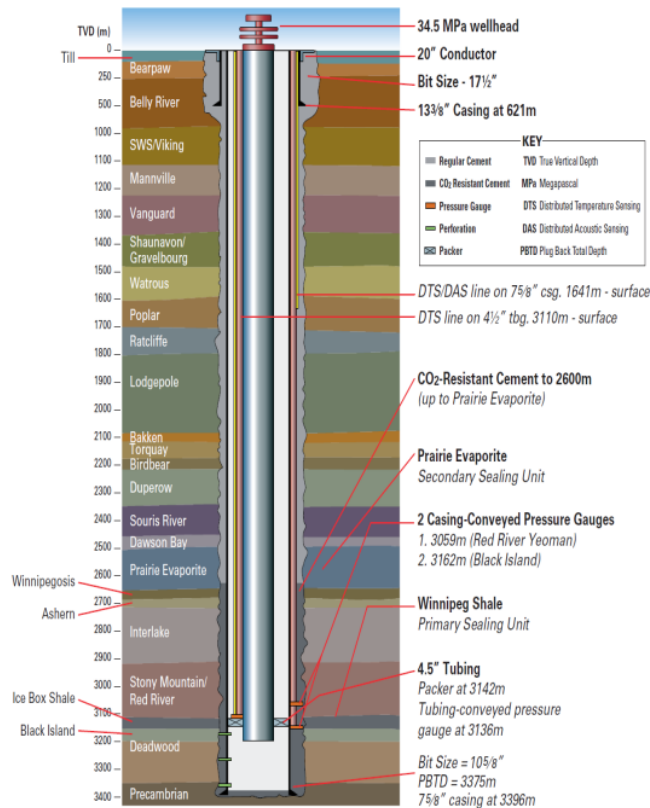
 **2100**  
MAX INJECTION RATE  
TONNES/DAY

**30**   
MONITORING  
TECHNOLOGIES DEPLOYED

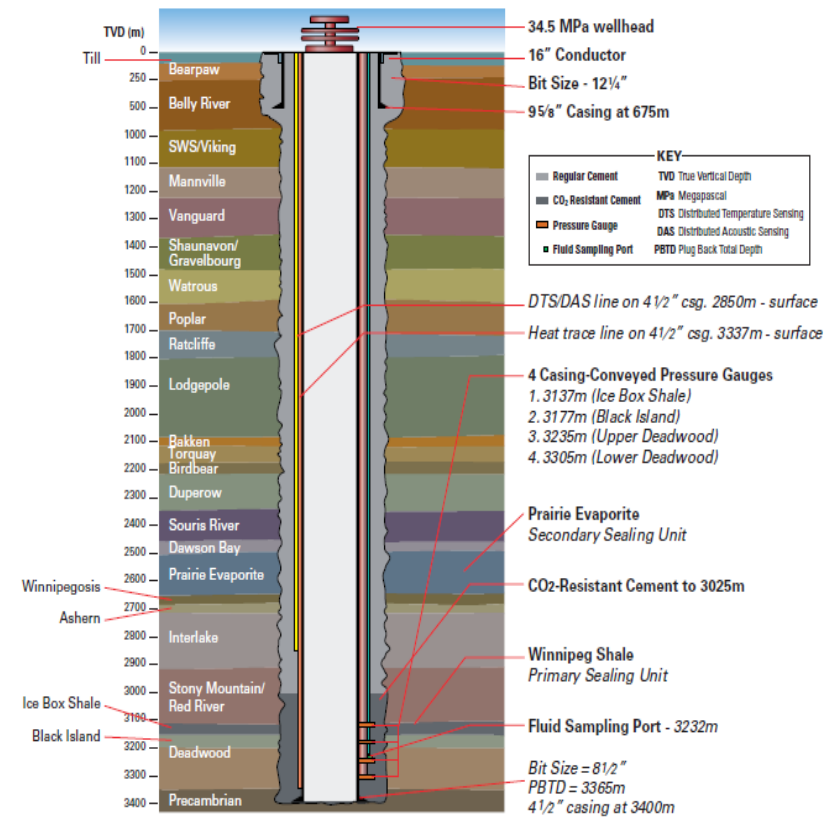
# DEEPEST WELLS IN SASKATCHEWAN



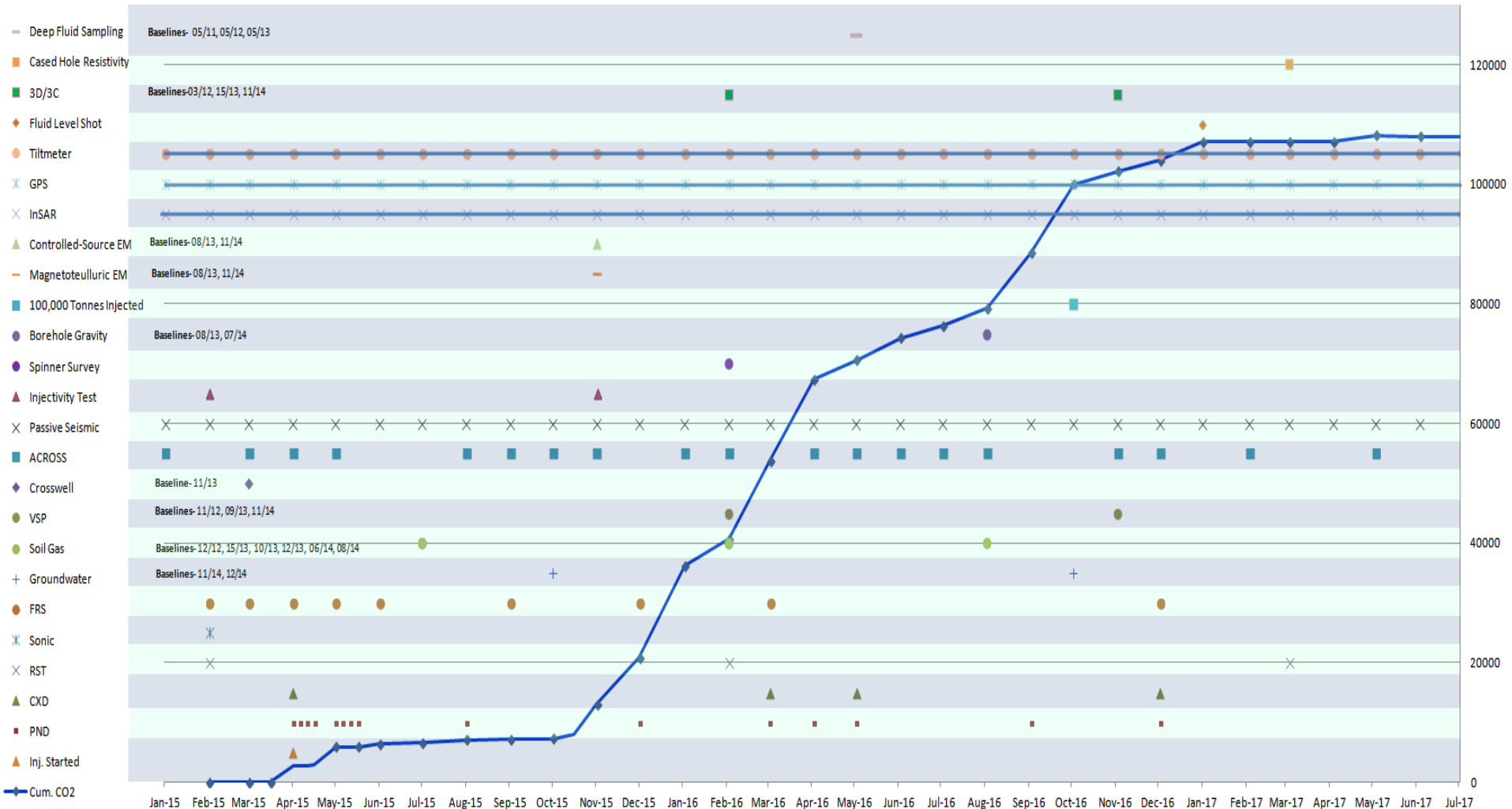
## Injection Well – 3396 m



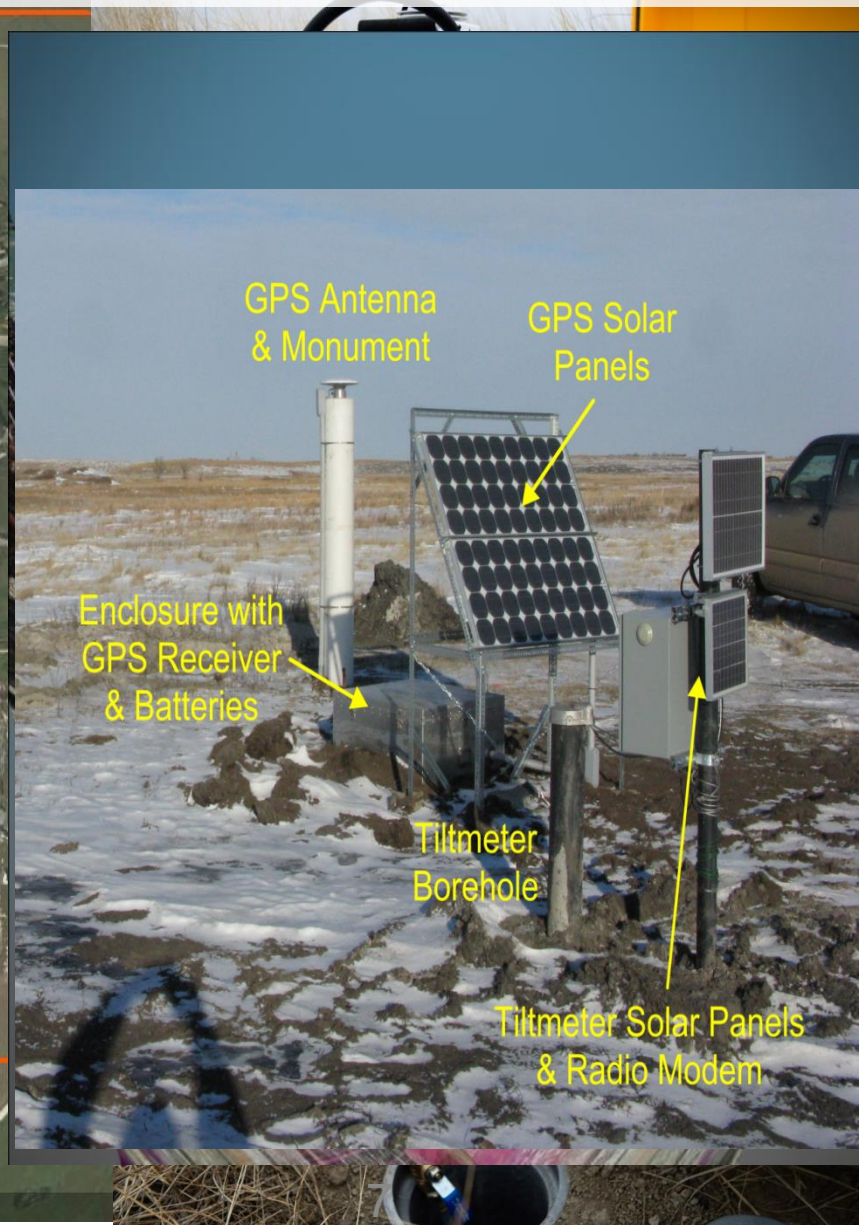
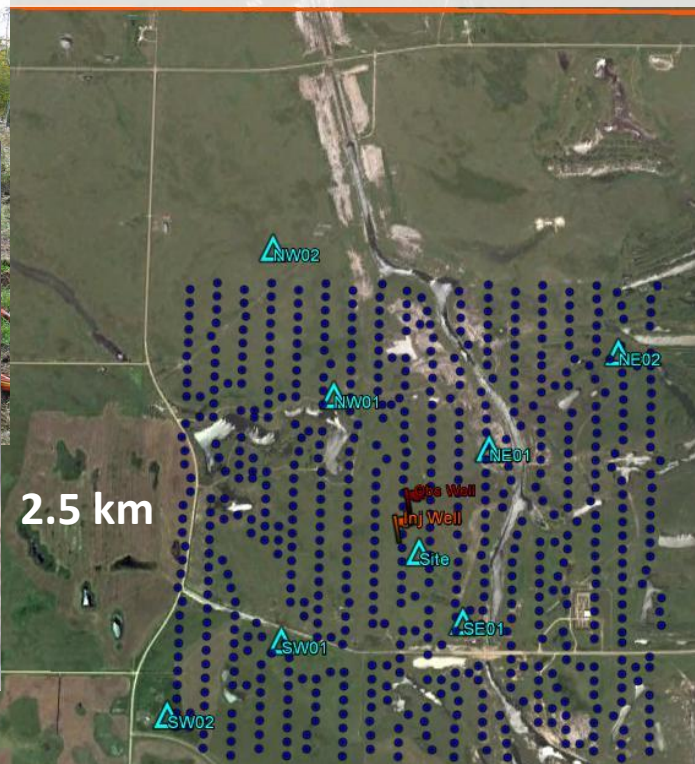
## Observation Well – 3400 m



# 2015-2017 MMV PROGRAM



# MONITORING INSTALLATIONS



# 3D TIME-LAPSE SEISMIC



## Baseline survey(March-2012)

- 3D Surface seismic
- 1kg explosives @20m
- Buried permanent receivers @15m

## Pre CO<sub>2</sub> Monitoring 1 (May-2013)

- 3D Surface seismic

## Pre CO<sub>2</sub> Monitoring 2 (Nov-2013).

- 3D Surface seismic
- 3D DAS VSP-I

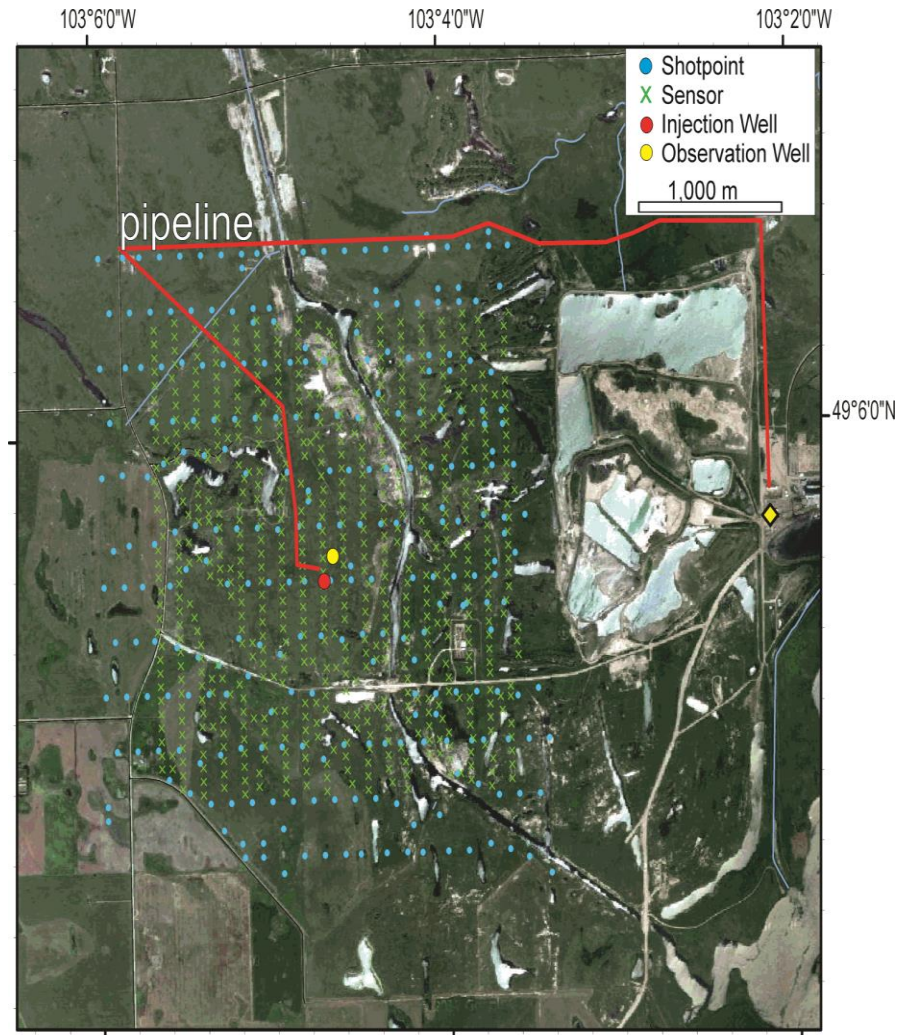
## CO<sub>2</sub> injection started (Apr 2015)

## Monitor 3 (Feb 2016) 36 kT CO<sub>2</sub>

- 3D Surface seismic
- 3D DAS VSP-II

## Monitor 4 (Nov 2016) 100 kT CO<sub>2</sub>

- 3D Surface seismic
- 3D DAS VSP-III

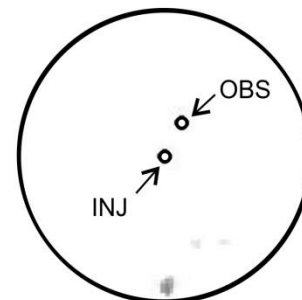
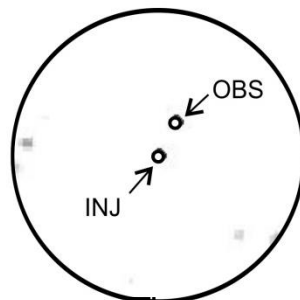
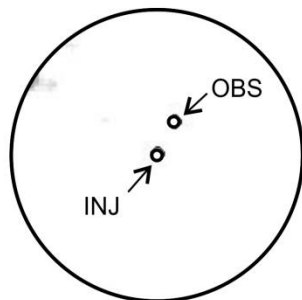




Monitor 2  
(0kT)

Monitor 3  
(36kT)

Monitor 4  
(105kT)

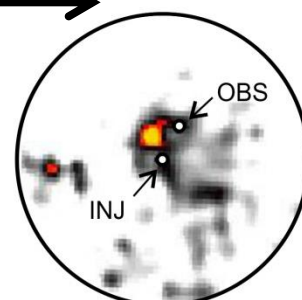
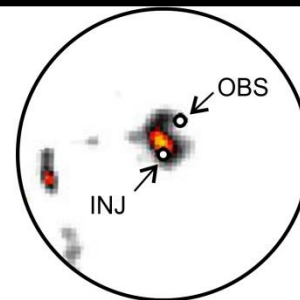
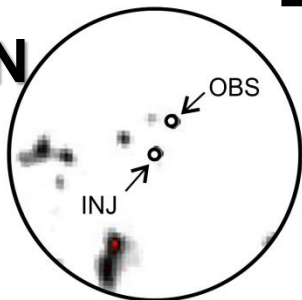


Black  
Island

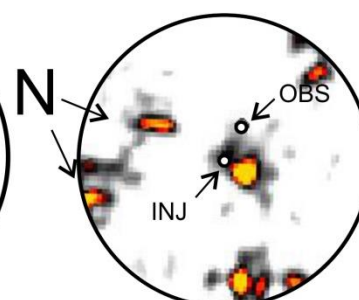
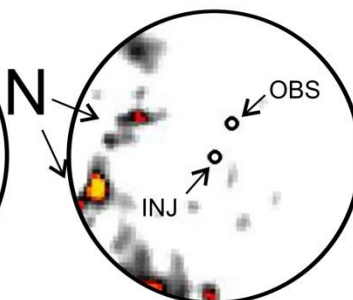
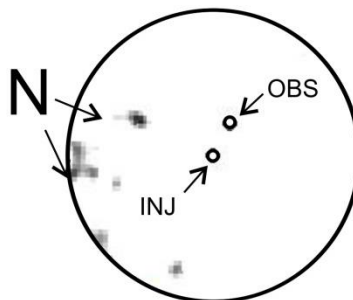
Time



# PLUME EVOLUTION



upper  
Deadwood



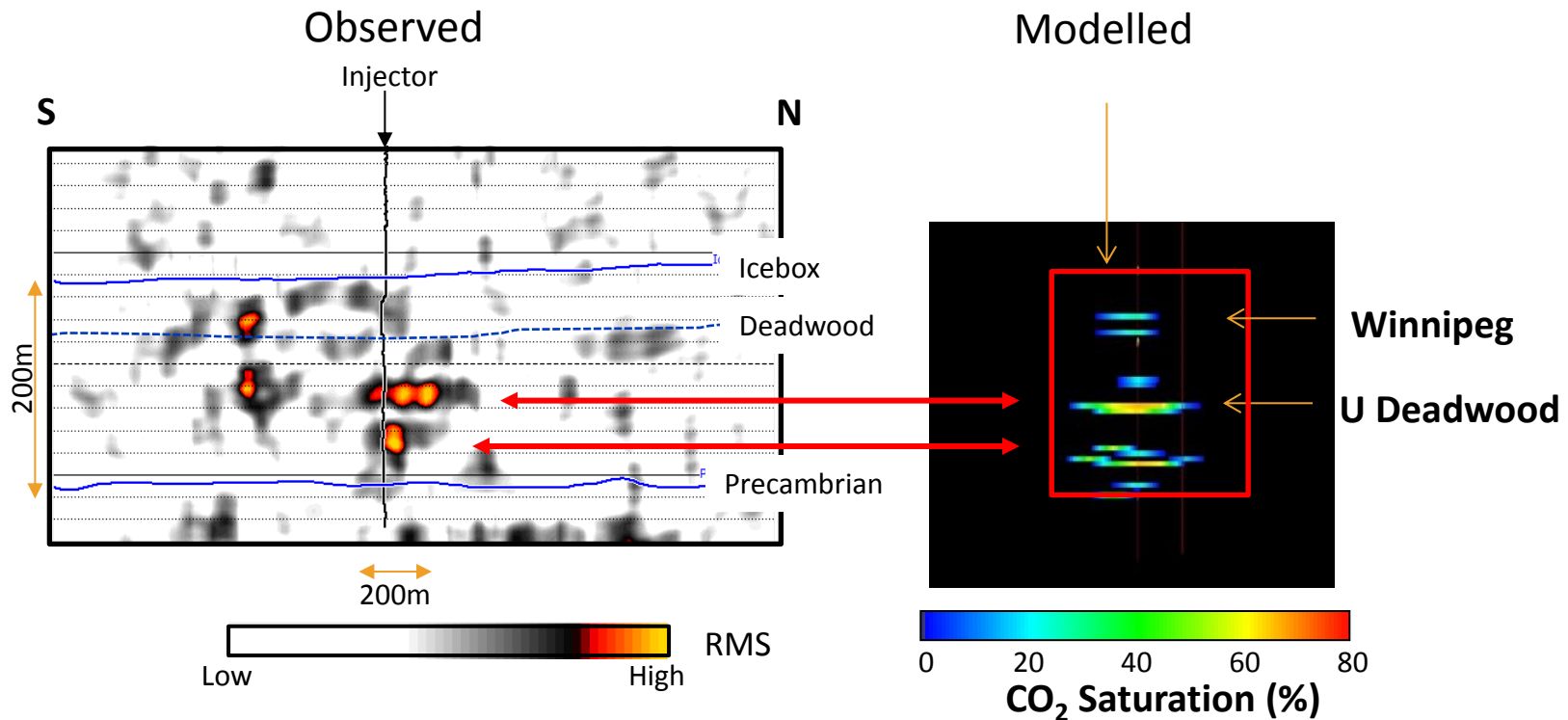
lower  
Deadwood

6 8 10 12 14 16 18 20%



NRMS

# OBSERVED SEISMIC VS. MODELLED CO<sub>2</sub> (105 kT INJECTED)

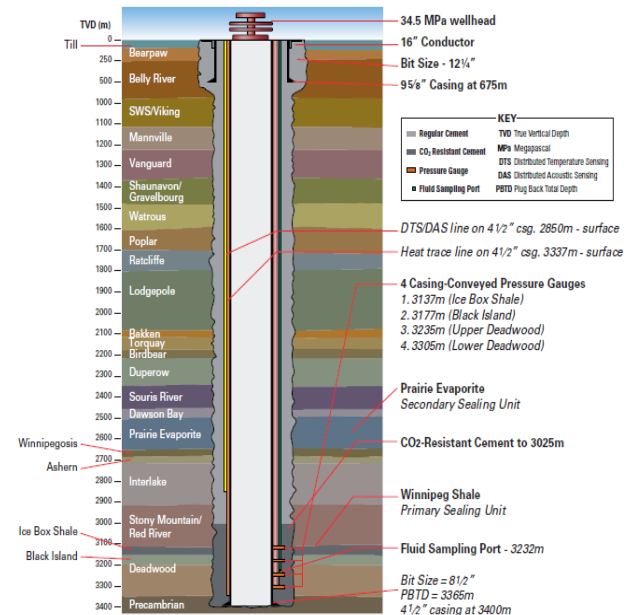
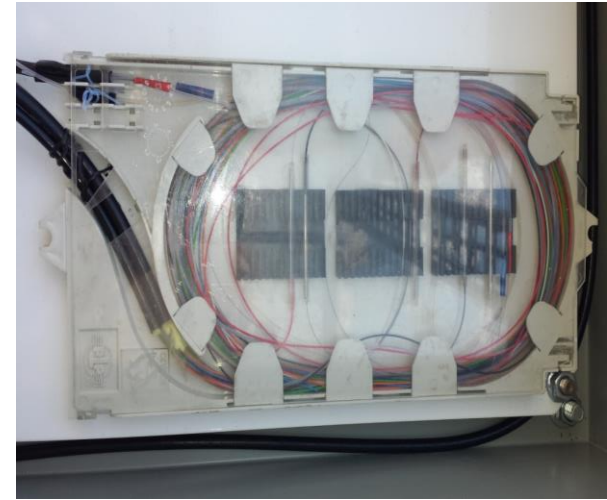


# TEST SITE FOR CASING CONVEYED AND BURIED FIBRE

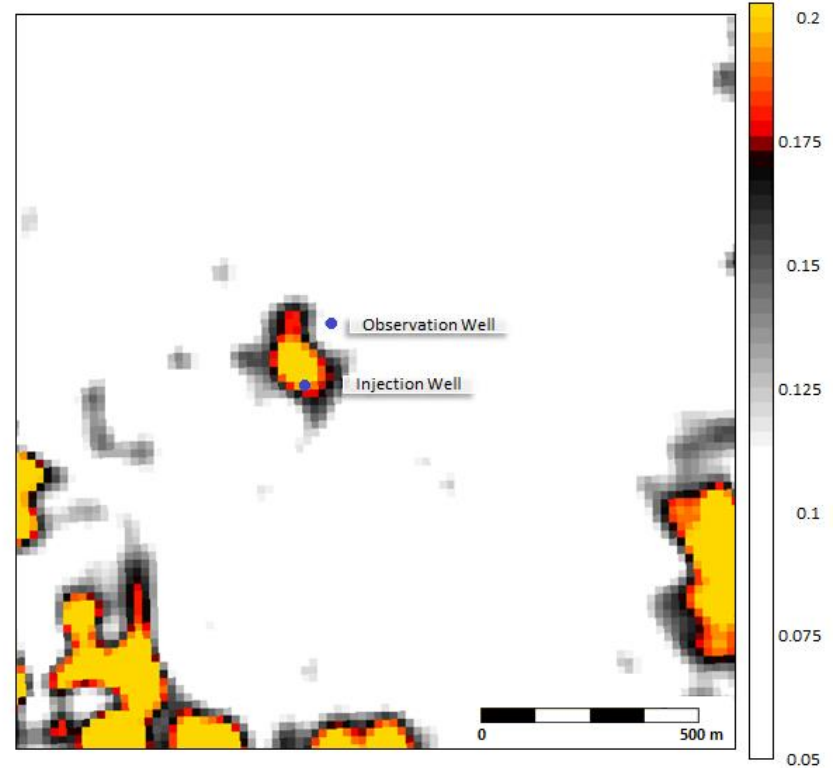
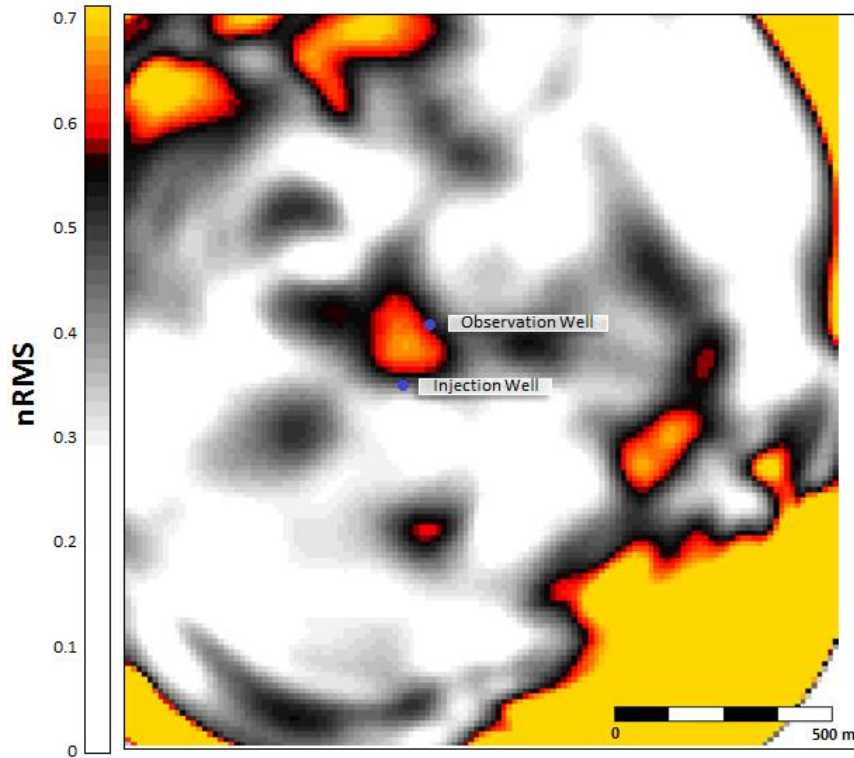


## DAS (Distributed Acoustic System)

- Distributed acoustic sensing (DAS) technology for seismic monitoring could revolutionize seismic imaging.
- Employs an optical fibre as a replacement for traditional geophones.
- High quality 3D imaging methods that are lower in cost to deploy than traditional geophone surveys
- Further research and demonstration will confirm monitoring capabilities that surpass the current standard technologies.
- Can be used for natural resources extraction (oil, gas), underground storage (CO<sub>2</sub>, wastewater) and in the potash and mining industries.

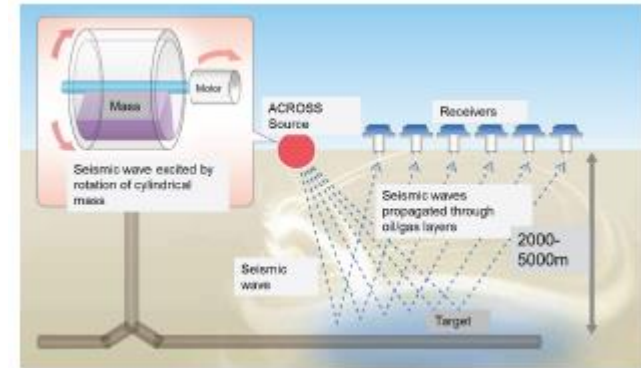


# MONITOR I DAS VSP DIFFERENCE





- **ACROSS (Accurately Controlled and Routinely Operated Signal System)**
- **Fixed in cement at surface, can produce repeatable, extremely precise two-component seismic signal**
- **Used in collaboration with Aquistore's 630 buried geophones.**



# INDUCED SEISMICITY MONITORING

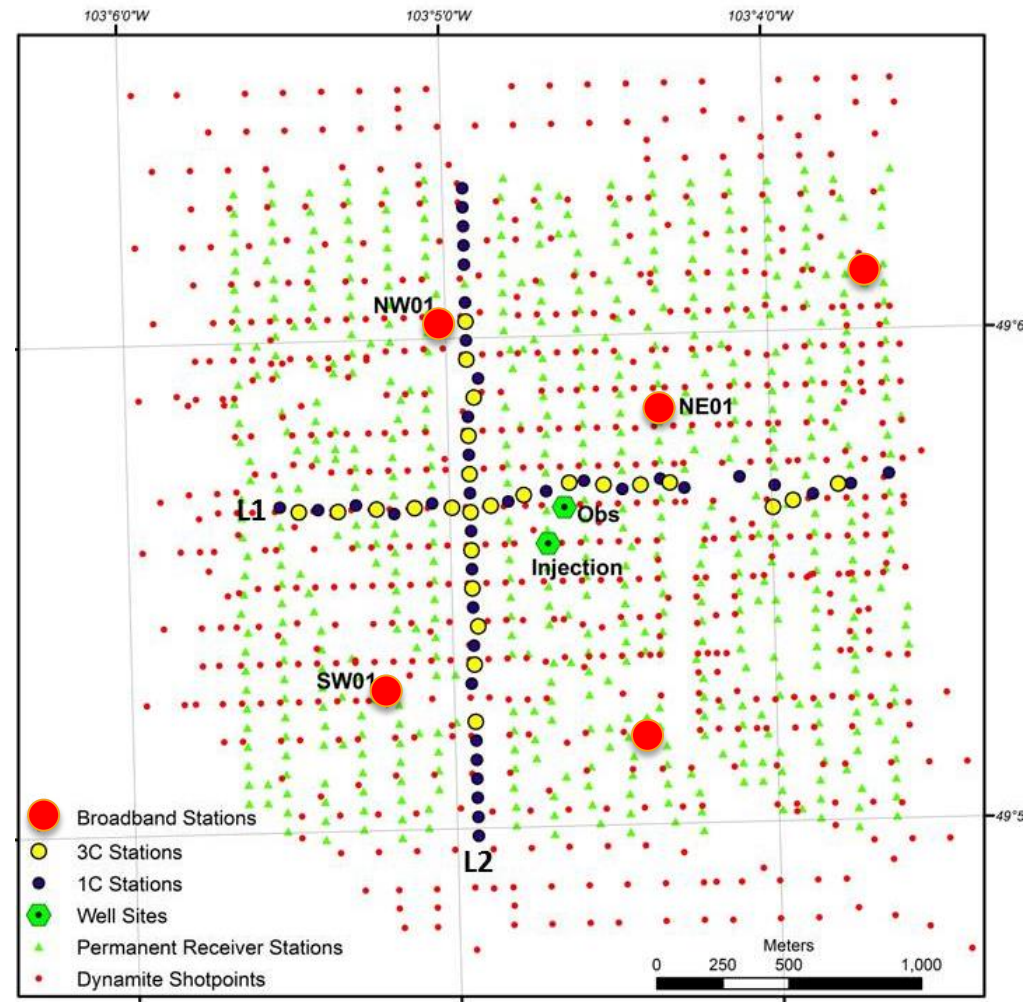


- No injection related seismicity ( $M_w > 1$ ) detected during first 2 years of operation.
- No smaller magnitude events ( $M_w > -3$ ) recorded during 8 month deployment of more sensitive downhole system.
- Local events: mining blasts recorded.
- Regional and teleseismic events have been detected and recorded.

Bristol University Microseismicity Projects  
BUMPS



Aquistore Seismic Monitoring Components

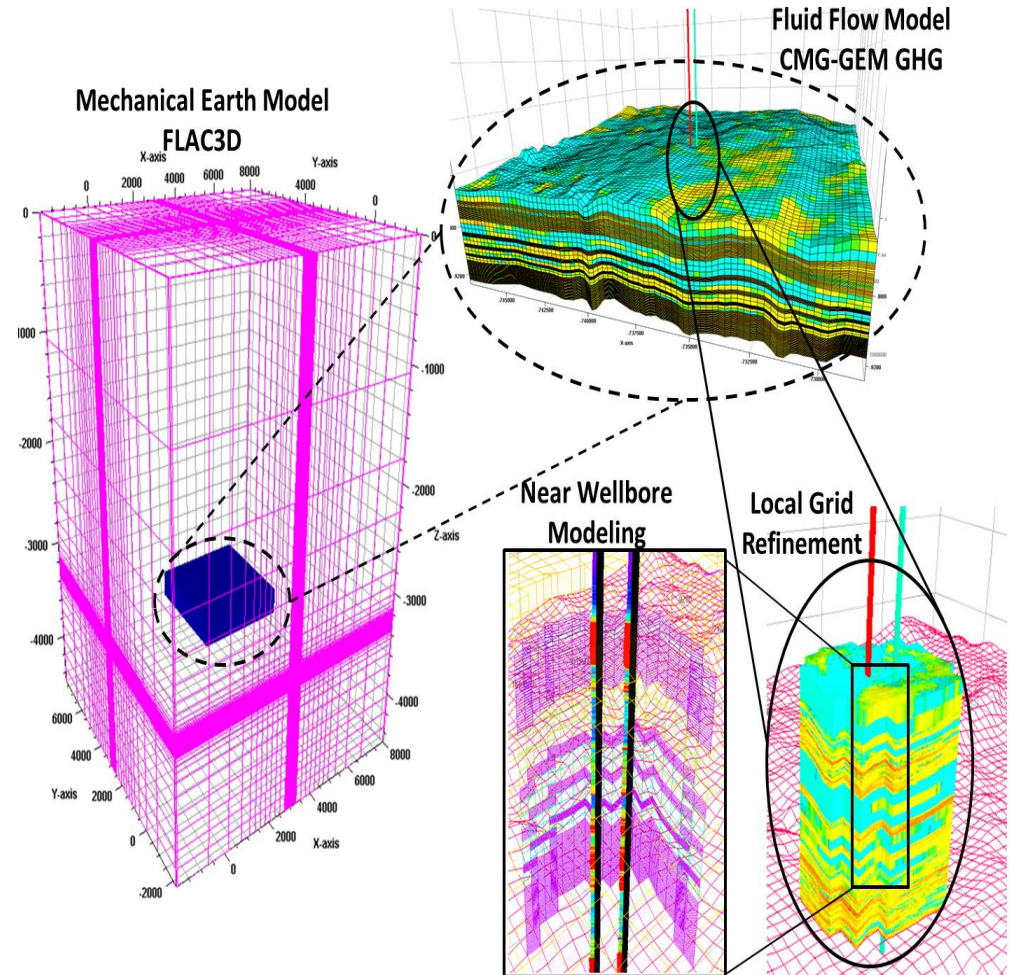




# GEOMECHANICAL COUPLED NON-ISOTHERMAL MODEL



- Cold CO<sub>2</sub> Injection
- Wellbore heat transmission
- Thermal effects in fluid/mineral reactions
- CO<sub>2</sub> thermo-physical behavior
- CO<sub>2</sub> injectivity
- CO<sub>2</sub> migration in cooled area
- Thermal fracturing
- CO<sub>2</sub> hydrates







- Small quantity of CO<sub>2</sub> at significant depth imaged with permanent and DAS seismic surveys.
- Evaluate impacts of a 75°F drop in downhole temperature
- Incorporate non-isothermal parameters into future reservoir simulations.
- Evaluate how variable rates of injected CO<sub>2</sub> may have an impact on injection well: casing, tubing, packer and cement integrity.
- Evaluate the impact on near-wellbore and long-term injectivity due to salt precipitation phenomena.



*“The continued success of this Project will have incredible implications for reducing CO<sub>2</sub> emissions throughout the world.”*

*- John Gale, IEA*

# THANKS TO OUR SPONSORS & IN-KIND COLLABORATORS



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