Midwest Geological Sequestration Consortium

Lessons Learned from Large-scale Projects: Illinois Basin – Decatur Project

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- The Midwest Geological Sequestration Consortium (MGSC) is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky.

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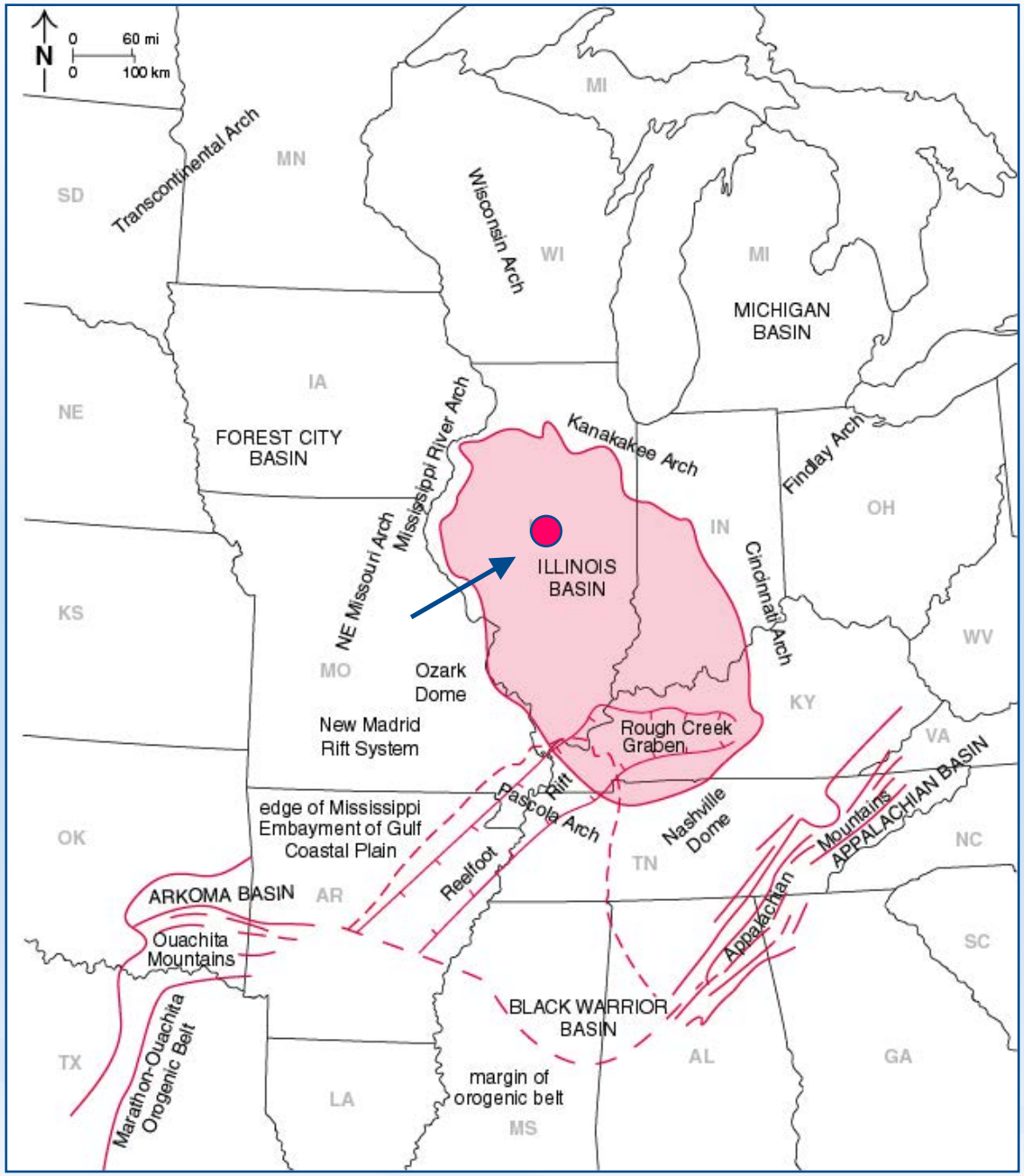
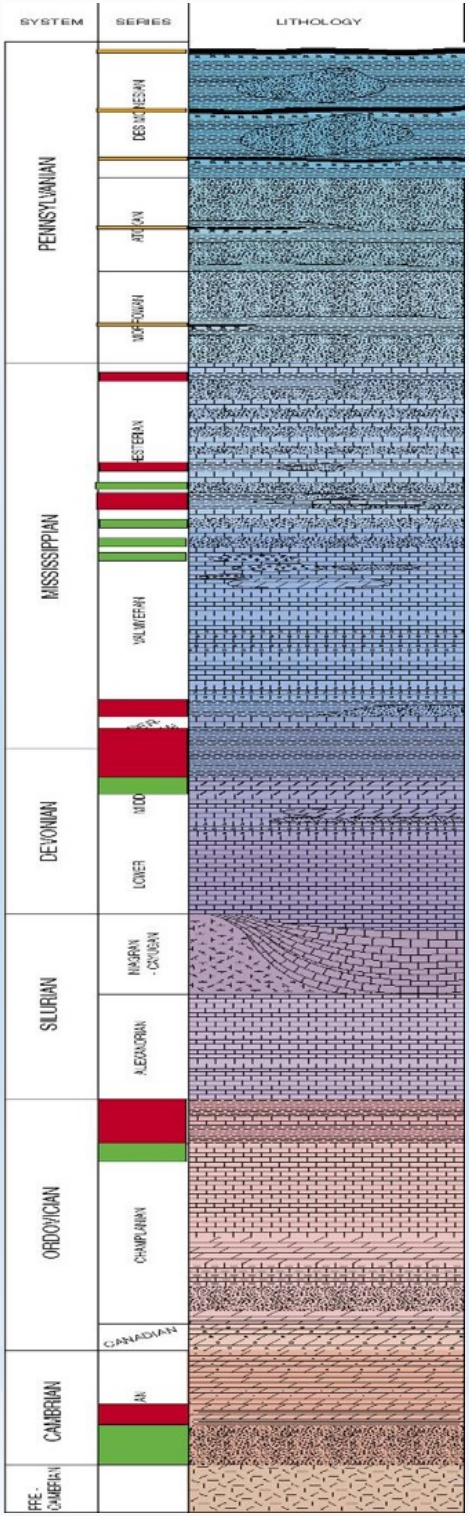
Illinois Basin – Decatur Project Scope



A collaboration of the Midwest Geological Sequestration Consortium, the Archer Daniels Midland Company (ADM), Schlumberger Carbon Services, and other subcontractors to inject 1 million metric tons of anthropogenic carbon dioxide at a depth of 7,000 +/- ft (2,000 +/- m) to test geological carbon sequestration in the Mt. Simon Sandstone, a saline reservoir, at Decatur, IL

- Prove injectivity and capacity
- Demonstrate security of injection zone
- Contribution to best practices

Illinois Basin Stratigraphic Column



Pennsylvanian coal seams

New Albany Shale

back-up seals

Maquoketa Shale

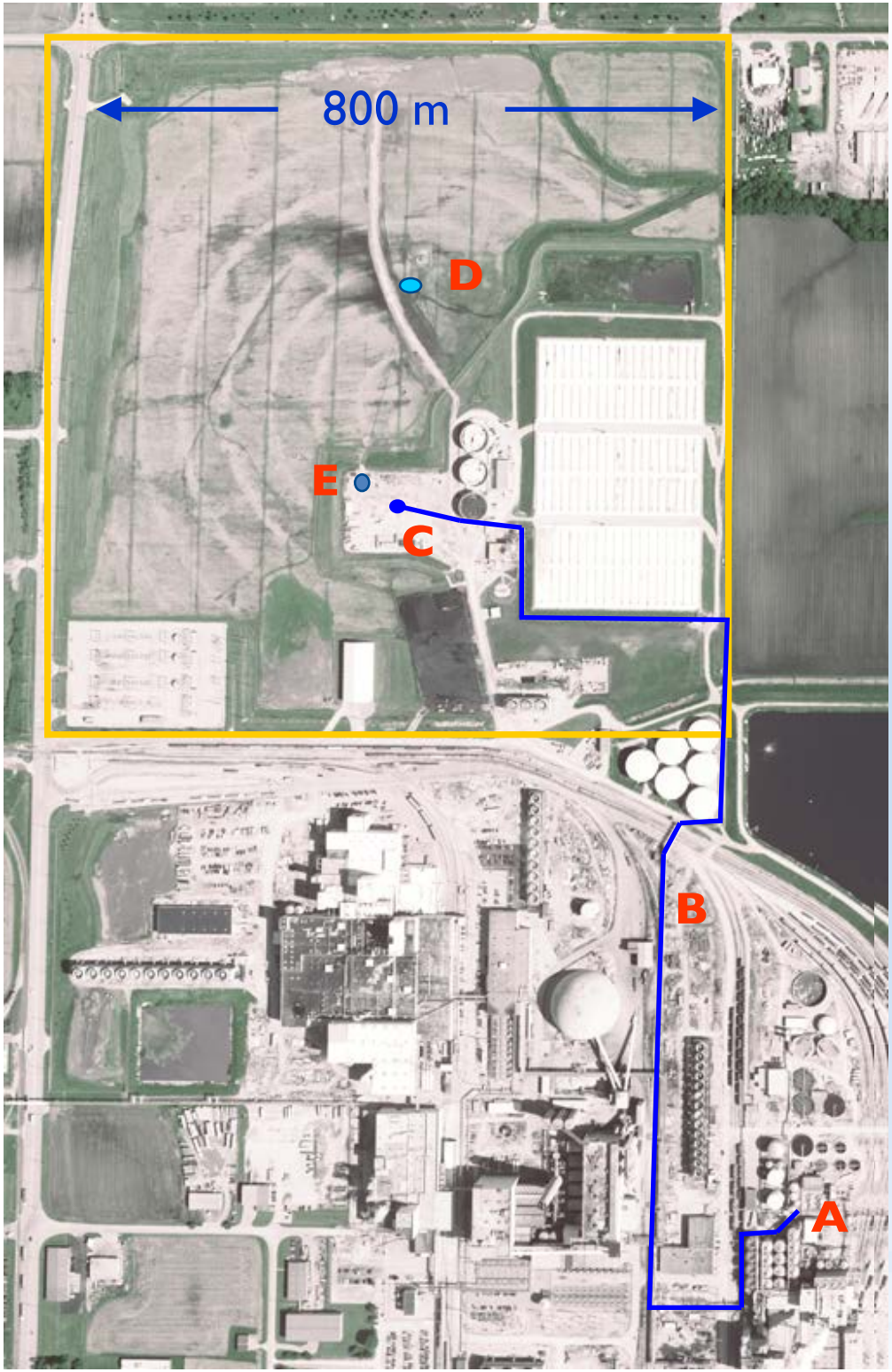
St. Peter Sandstone

Eau Claire Shale seal

Mt. Simon Sandstone reservoir

Mount Simon Storage Capacity:

11 (E=0.4%) to 150 (E=5.5%) billion metric tons



Illinois Basin – Decatur Project Site (on ADM industrial site)

A Dehydration/ compression facility location

B Pipeline route (1.9 km)

C Injection well site

D Verification/ monitoring well site

E Geophone well

Operational Injection: November 2011 to 2014

- IBDP is the first 1 million tonne carbon capture and storage project from a biofuel facility in the US
- Intensive post-injection monitoring under MGSC through 2017
- Industrial CCS Injection Monitoring through 2019

Total Injection:
999, 215 tonnes

Key Operational Results – IBDP at Completion of Injection

- Mount Simon Sandstone reservoir accepted CO_2 more easily than expected resulting in quicker detection at verification well
- Upward plume growth limited by reservoir permeability stratification, as modeled, and confirmed by pressure observations
- Resulting plume believed thinner than expected and was not detected with a 3D vertical seismic profile until April 2013
- Mt. Simon 200,000 ppm brine is more corrosive than expected
- With 999,215 tonnes injected, CO_2 remains in lowermost Mt. Simon; internal reservoir heterogeneity affecting CO_2 distribution
- No CO_2 leakage or adverse impacts detected to date
- Second project (ICCS) will add opportunity to monitor two plumes

Post-Injection Activities (Since November 2014)

- Post-injection near surface and deep monitoring
- Post-injection modelling and data evaluation
  - 3D Surface Seismic Survey – 2015
  - Post-injection VSP (permit interim period) – 2015
  - RTAC to Well Watcher Migration - 2016
  - Recomplete VW1 – 2016
  - Final static and dynamic models – 2016
  - Near-surface monitoring analysis and recommendations - 2016
  - Passive/active monitoring project (US-Norway) – 2016-2017
  - Peer-reviewed articles, technical and final reports
- Knowledge and data sharing best practices
- Preparing IBDP site for long-term commercial viability
- Permit monitoring for ADM Industrial CCS project

IBDP Risk Assessment and Project Uncertainties

Geologic Uncertainty
Operational Uncertainty
Regulatory Uncertainty
Social Uncertainty

Regulatory Uncertainty

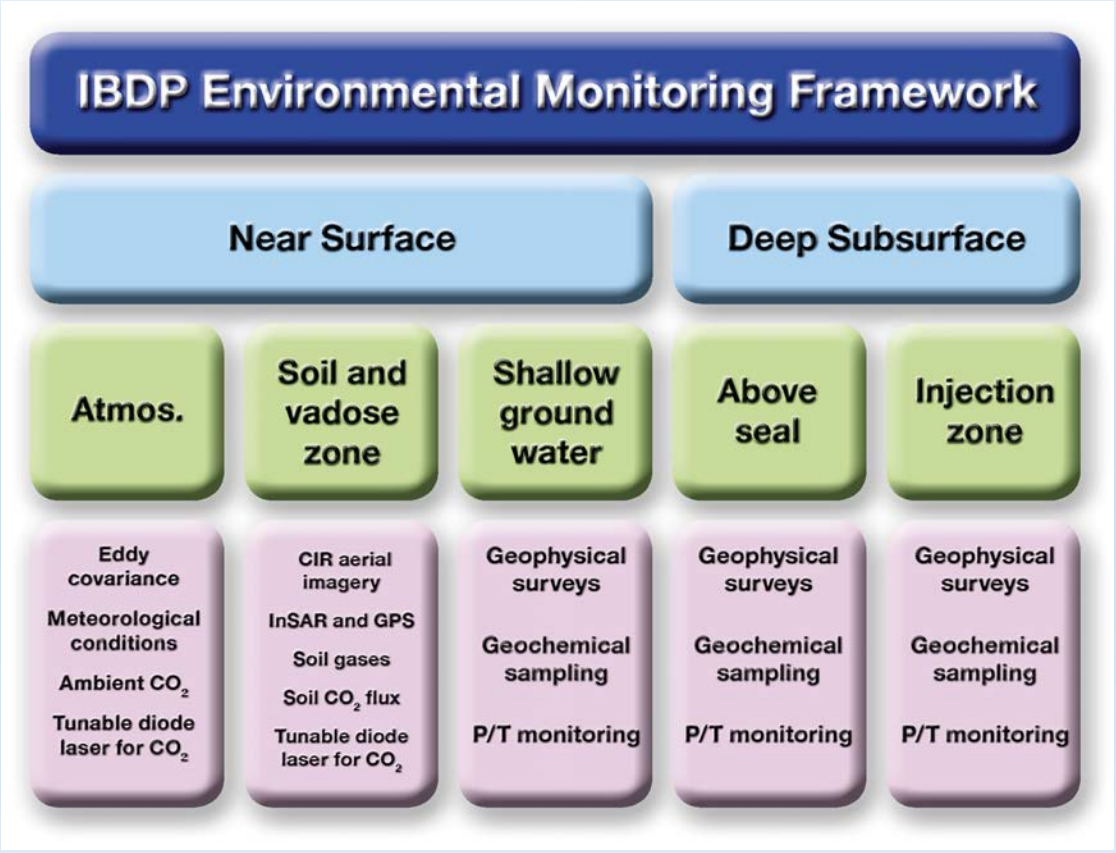
Change in Scope
Long-term Funding
Challenges in Knowledge Sharing
Complacency Potential
Institutional Memory Loss

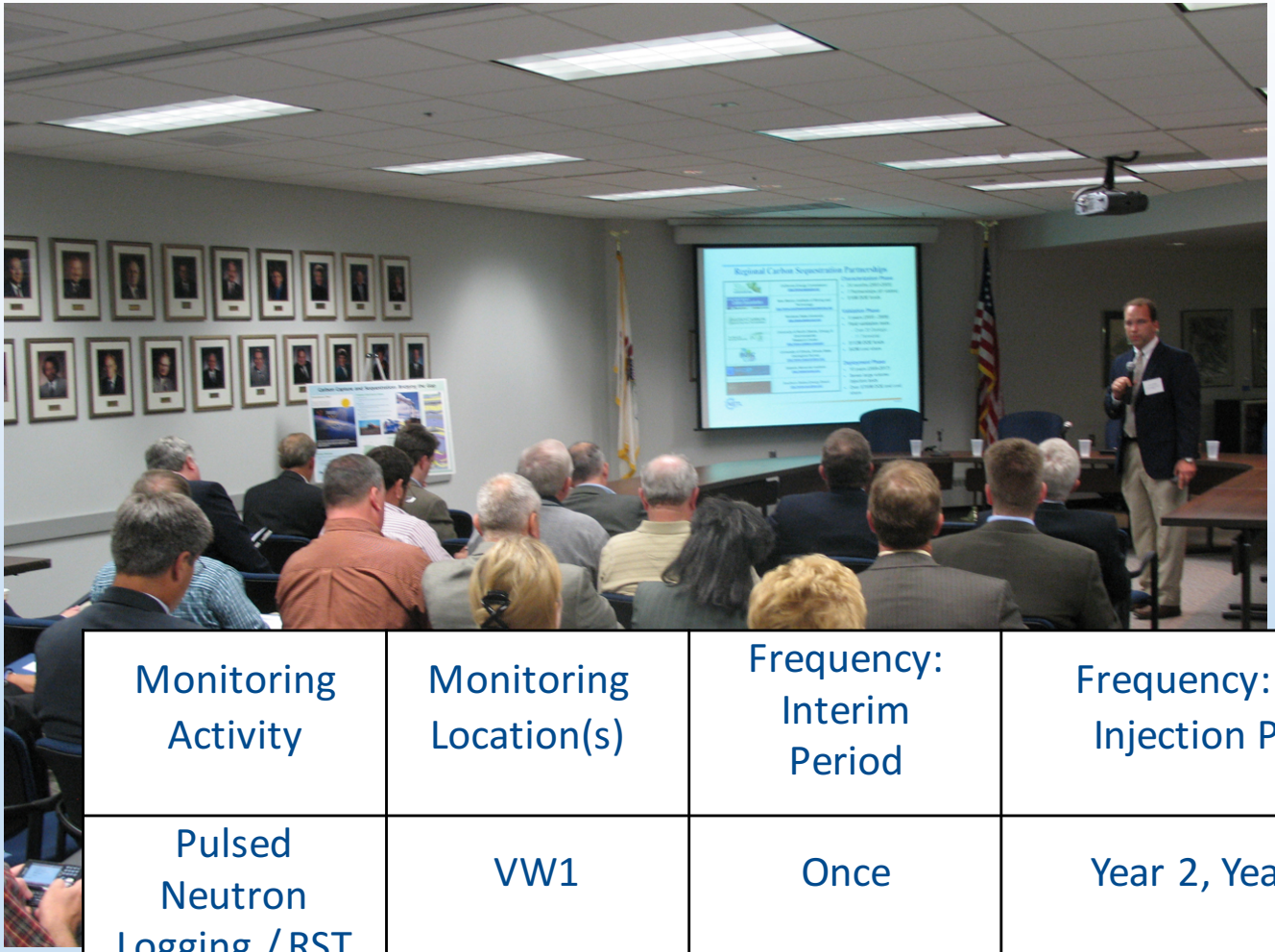
Regulatory Uncertainty

Funding Uncertainty
Transferring Knowledge
Sharing Data
Maintaining Capacity
Finishing Strong

Post-injection Monitoring – Locke and Collaborators

- Near-surface comparison with baseline
- Regulatory compliance for the IBDP PISC
- Recommendations for commercial-scale MVA operations based on IBDP experiences



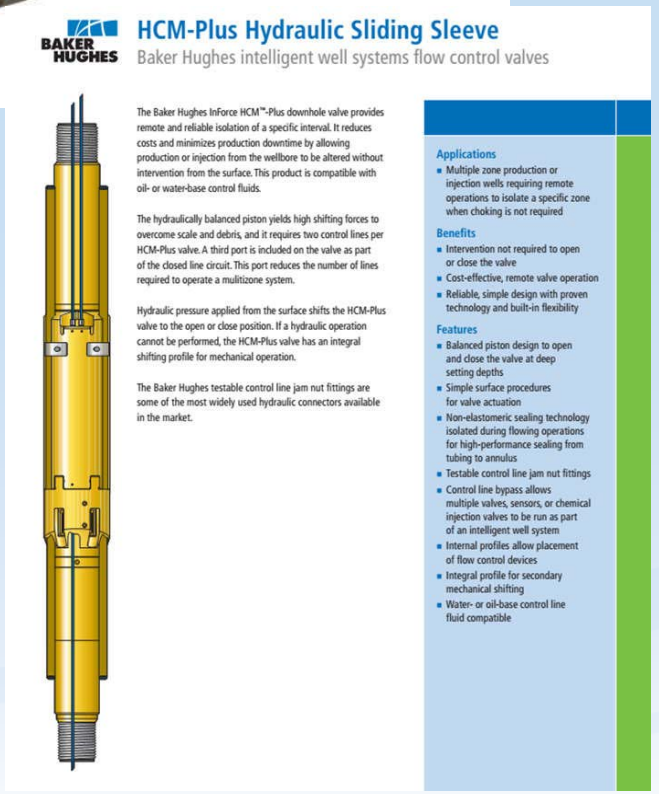


Permitting

IL EPA UIC Class I to US EPA UIC Class VI

Monitoring Activity	Monitoring Location(s)	Frequency: Interim Period	Frequency: CCS2 Injection Phase	Frequency: CCS2 Post- Injection Phase
Pulsed Neutron Logging / RST	VW1	Once	Year 2, Year 4	Year 1, Year 3, Year 5, Year 7, Year 10
Fluid Sampling	VW1	Once	Year 1-3 : Annual Year 4-5 : None	None
Pressure/ Temperature Monitoring	VW1	Continuous	Year 1-3 : Continuous Year 4-5 : None	None

Recompletion of VW1 Monitoring Well



- Option 1 – Retain Westbay
- Option 2 – Schlumberger IntelliZone
- Option 3 – Baker Hughes Intelligent
- Option 4 – Drill new well

Two Fluid Sampling and Four Pressure Zones

Research priorities:

- Monitor injection of multiple plumes within Mt. Simon in order to **determine and observe reservoir response** via pressure, temperature, geophysical, geomechanical, and geochemical means.
- **Demonstrate and test monitoring equipment and methodologies** for deployment at the near and deep subsurface through a comprehensive MVA program.
- **History match and determine plume development response** through active and passive seismic monitoring in order to further understand reservoir microseismic response

Project management priorities:

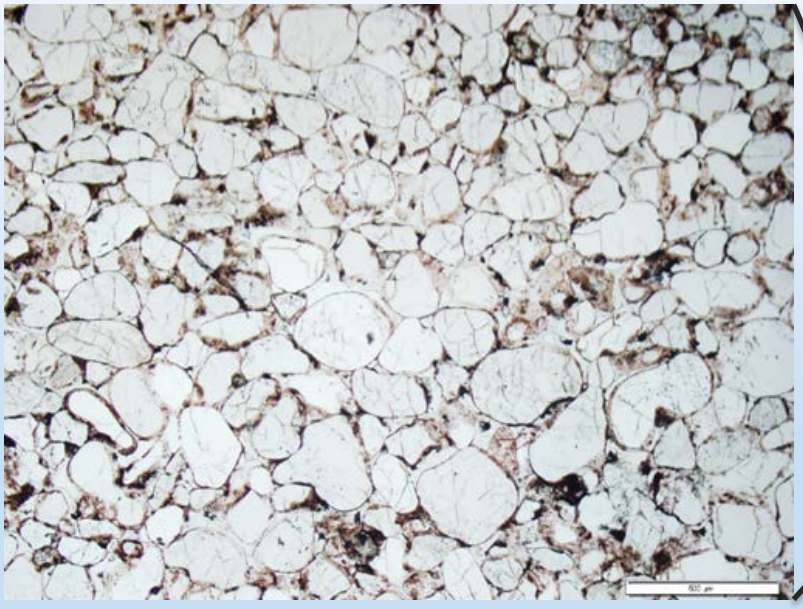
- **Deliver project on-time and within budget**
- **Reduce short- and long-term risk to project**

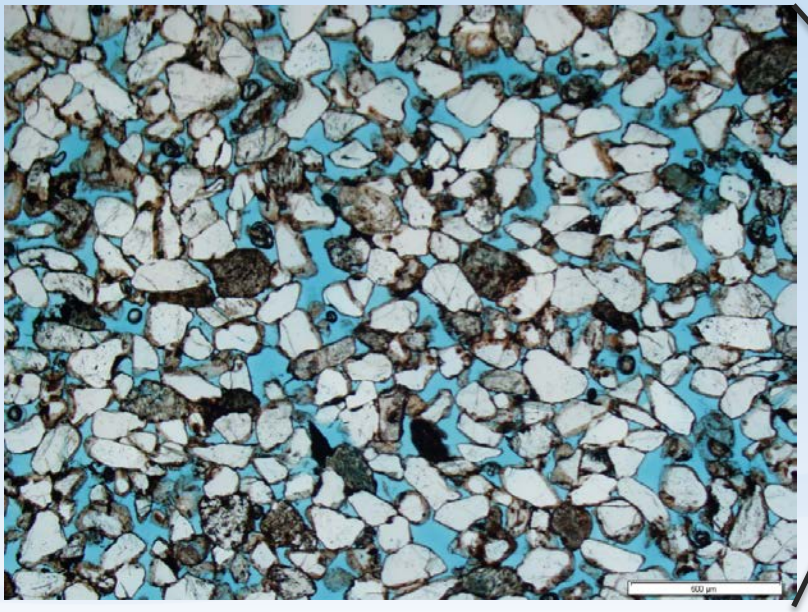
Permit priorities:

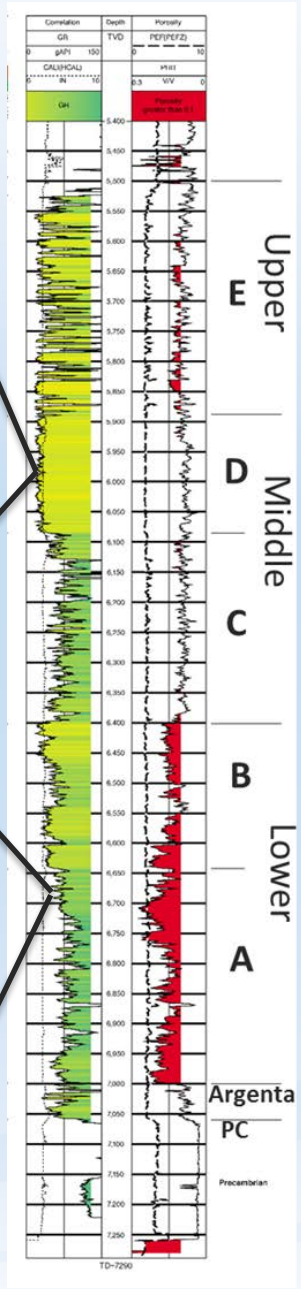
- **Perform Injection phase monitoring by fluid sampling** in two zones (one in Mt. Simon and one in Ironton/Galesville)
- **Perform continuous pressure and temperature monitoring**
- **Conduct direct and indirect plume monitoring**

Refined view of Lower Mt. Simon Depositional and Diagenetic History - Freiburg and Collaborators

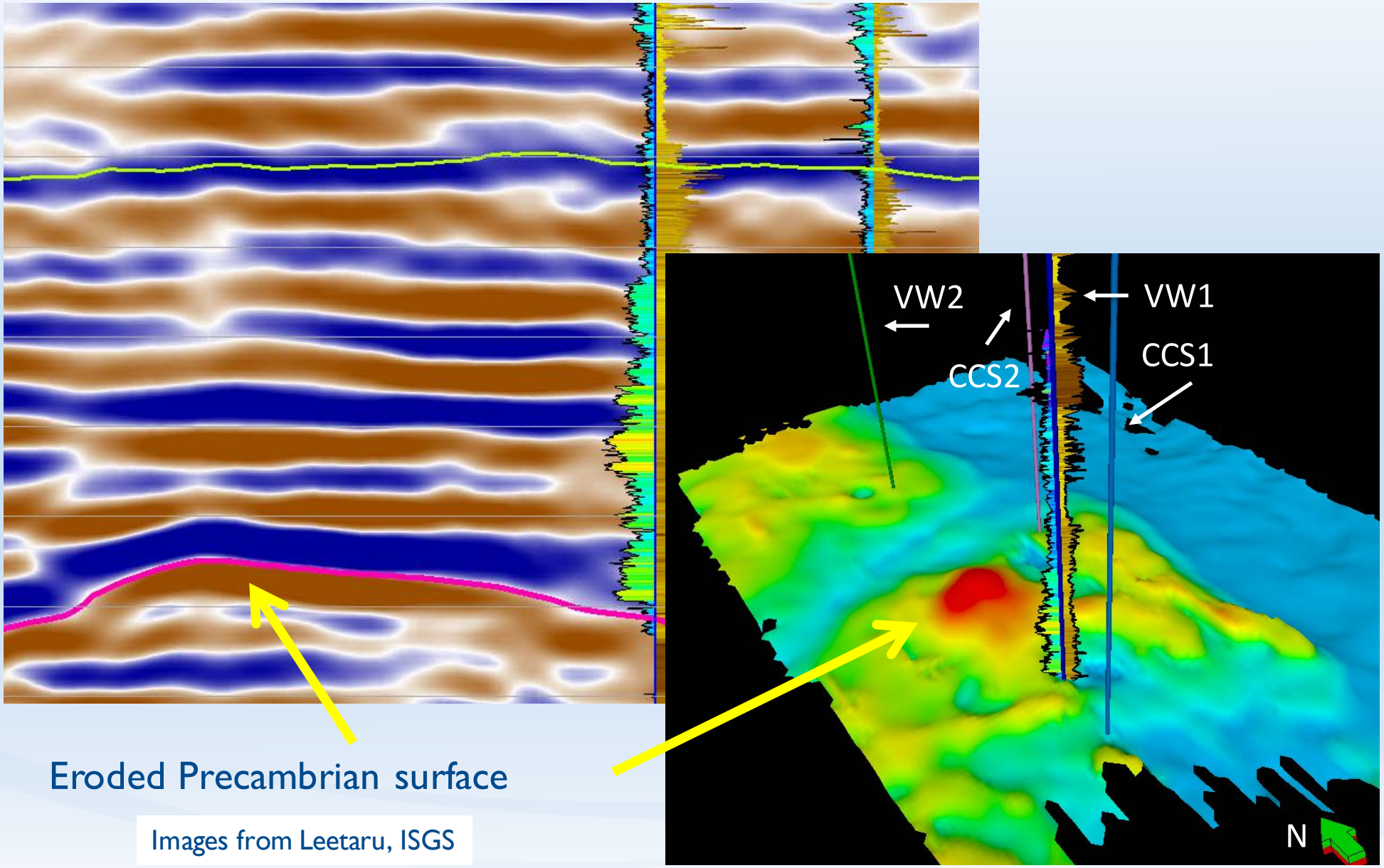
- Diagenetic controls on reservoir properties
- Depositional interpretation







Refining Understanding of Precambrian Structure using 3D Seismic Volume – McBride, Leetaru, and Collaborators



Eroded Precambrian surface

Images from Leetaru, ISGS

Gaining insights into microseismic activity

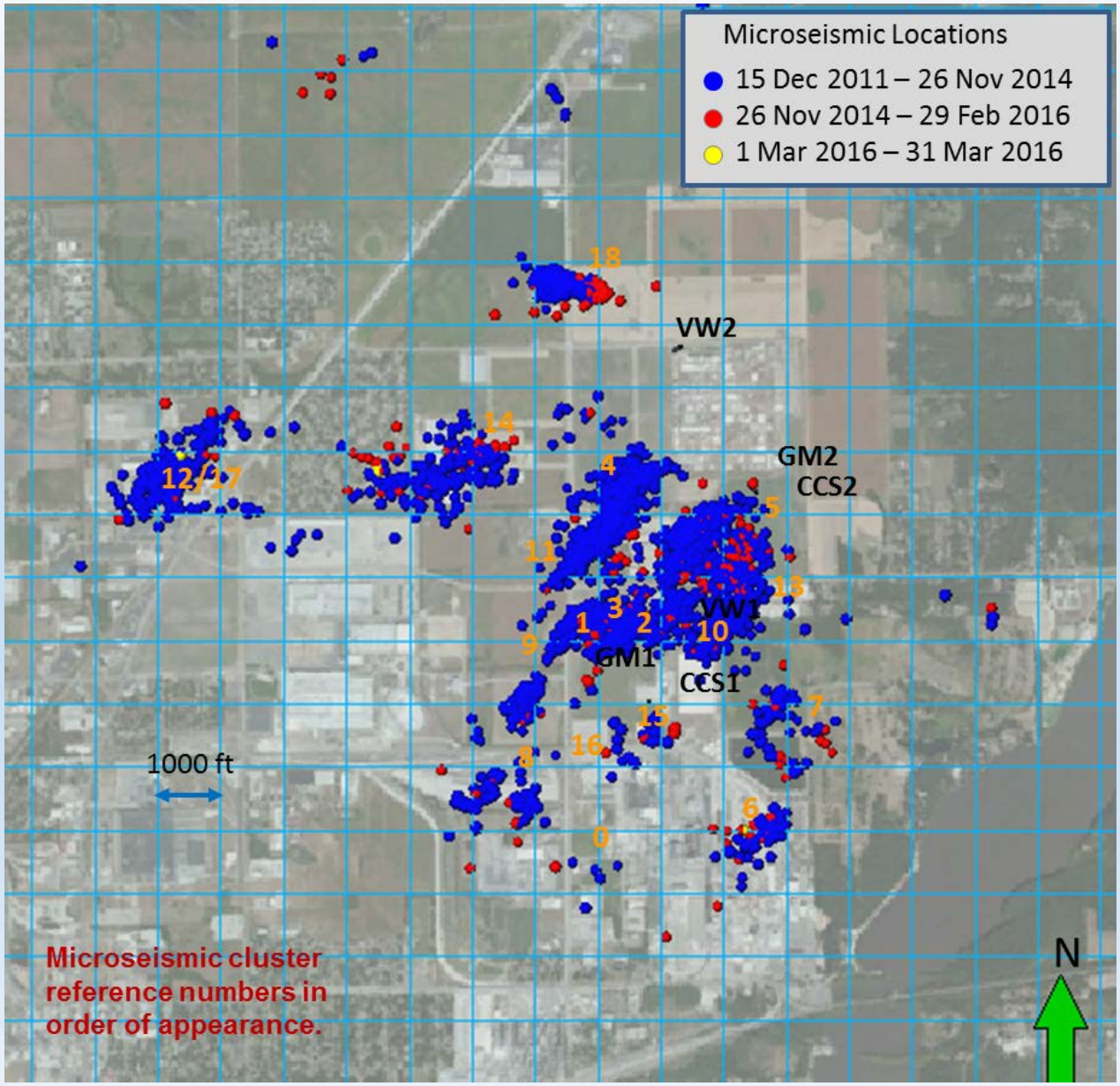


Image provided by Schlumberger Carbon Services

Gaining insights into microseismic activity

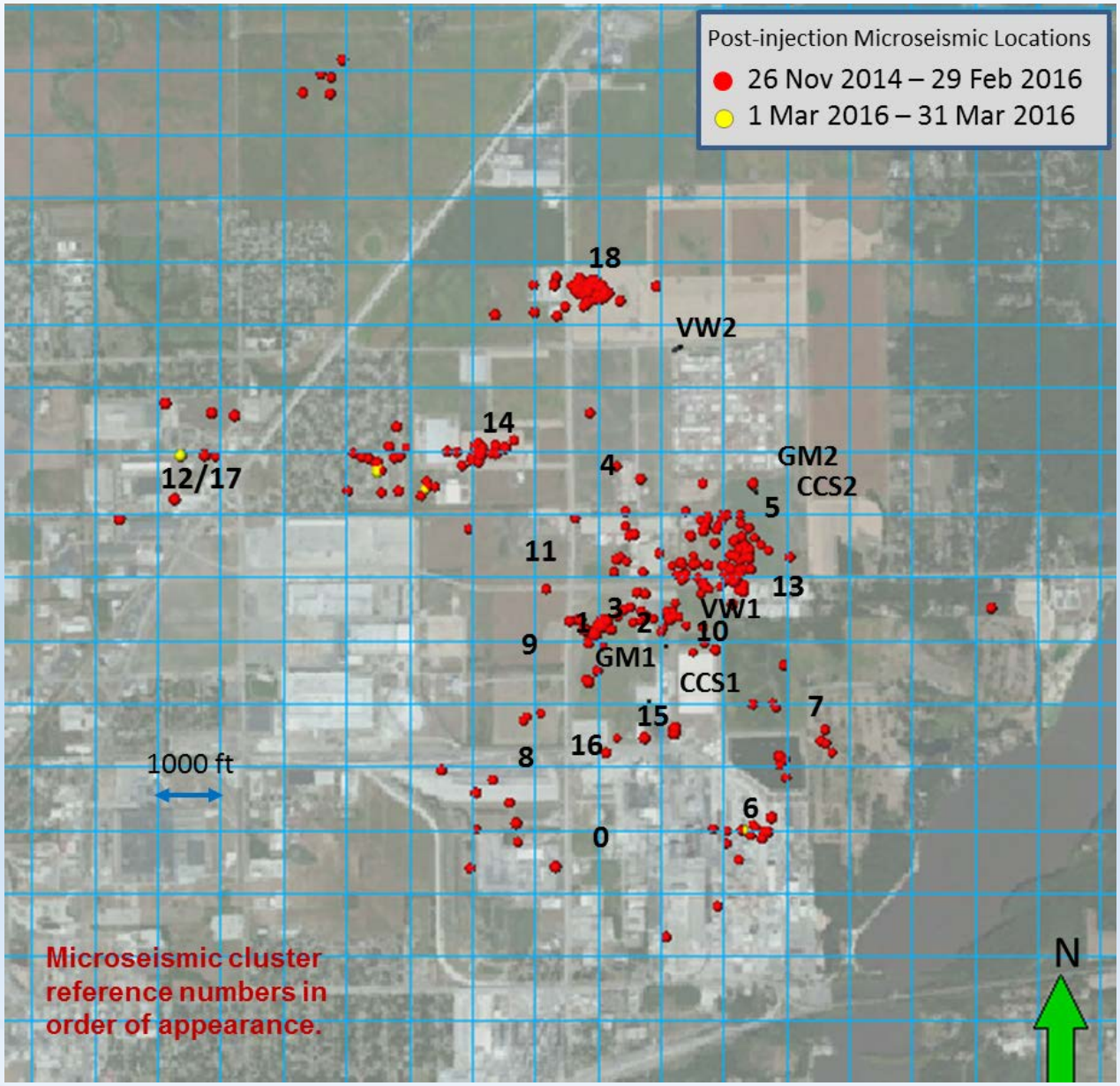
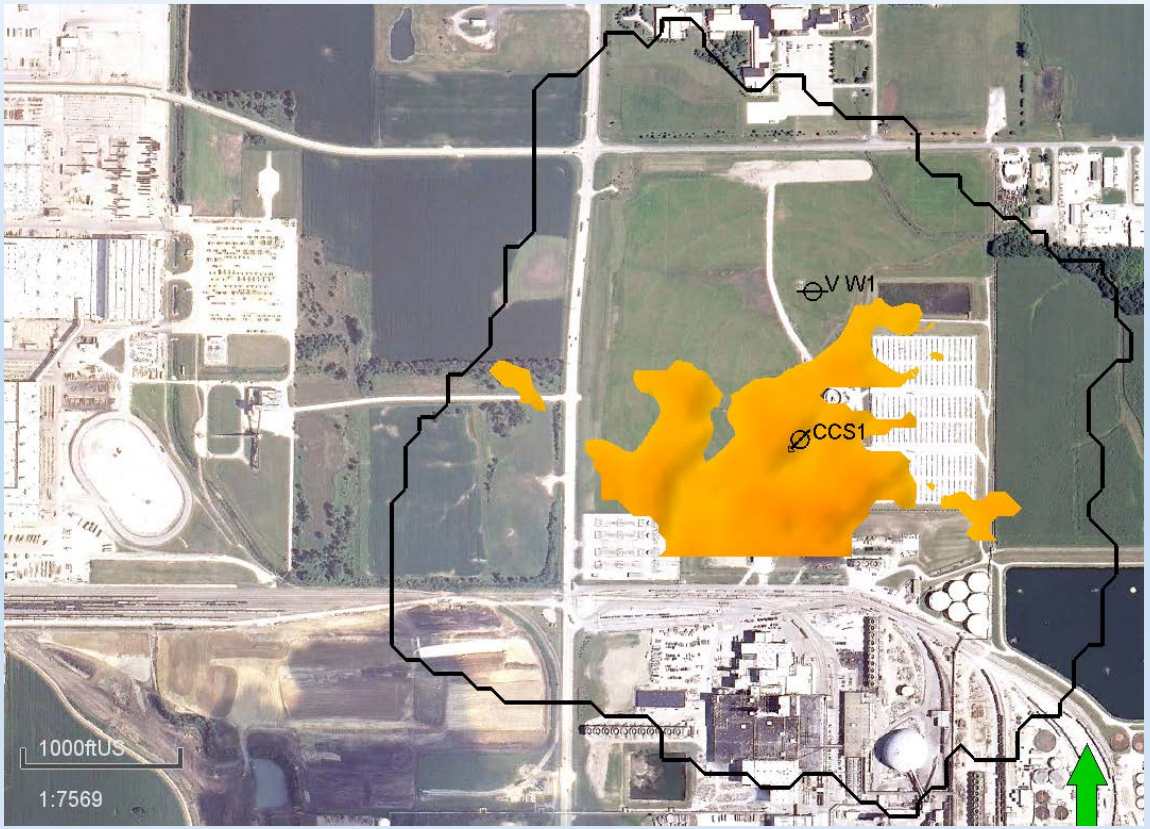


Image provided by Schlumberger Carbon Services

Integration of Modeling Efforts

- Concurrent IBDP Modeling Efforts:
  - Geologic (static)
  - Reservoir simulation
  - Geomechanical
  - Coupled hydro-mechanical



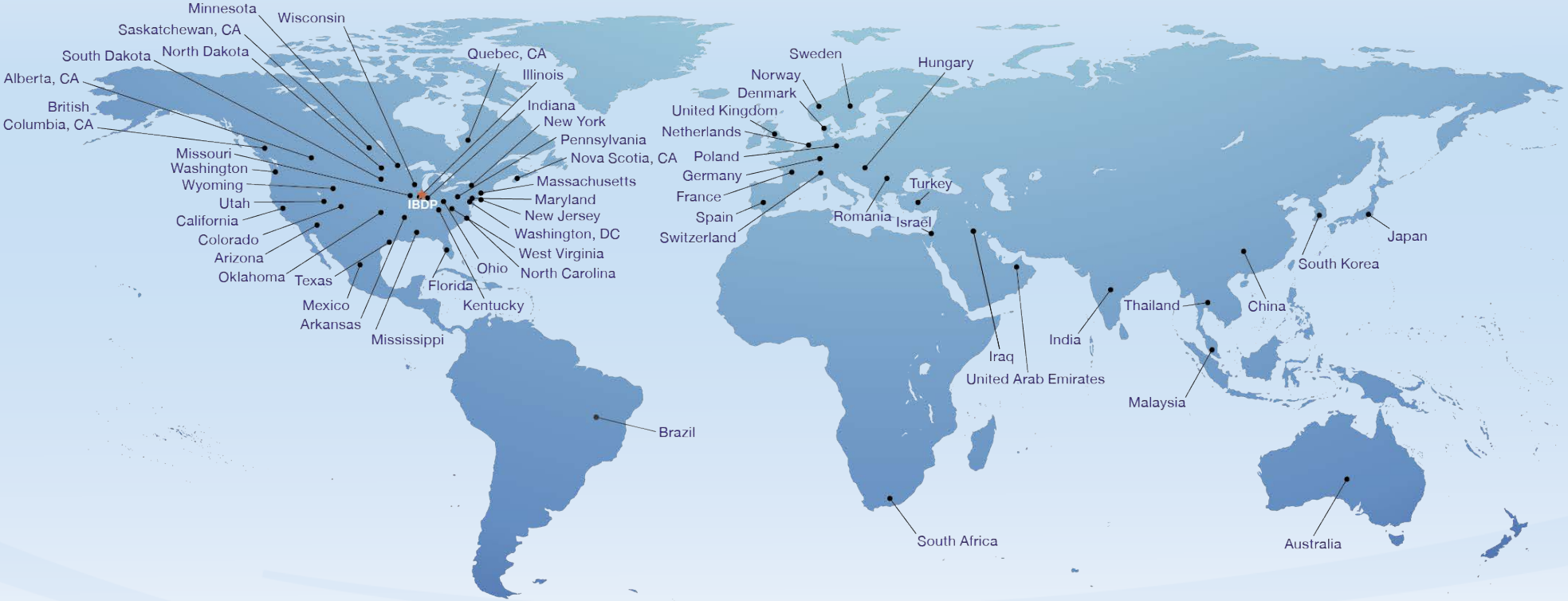
Preliminary consolidated time-lapse attribute interpretation (orange) and outline of modeled plume (black polygon) in Q1 2015.

By the numbers:

- A million tonnes stored and…
- More than **17,000 feet** of wells have been drilled
- More than **800 feet** of core have been collected
- Near-surface groundwater monitoring efforts have resulted in more than **50,000 analyses**
- For basin-scale modeling, we will use **1,020,000 CPU-hours** of XSEDE supercomputing resources.
- More than **700 visitors from 29 countries** have been to IBDP
- Over **180 publications** and **435 presentations**
- More than **100 people at least 10 organizations** have worked together to make this project a success

XSEDE is an NSF-sponsored supercomputer network

Global Participants Attending STEP-IBDP Events



Global STEP
Education and Outreach Events

*All International STEP Activities Were Paid From Non-Contract Funds

CCS in Decatur, IL USA

Illinois Basin – Decatur Project

- Large-scale demonstration

- Volume: 1 million tonnes
- Injection period: 3 years
- Injection rate: 1,000 tonnes/d
- Compression capacity: 1,100 tonnes/day

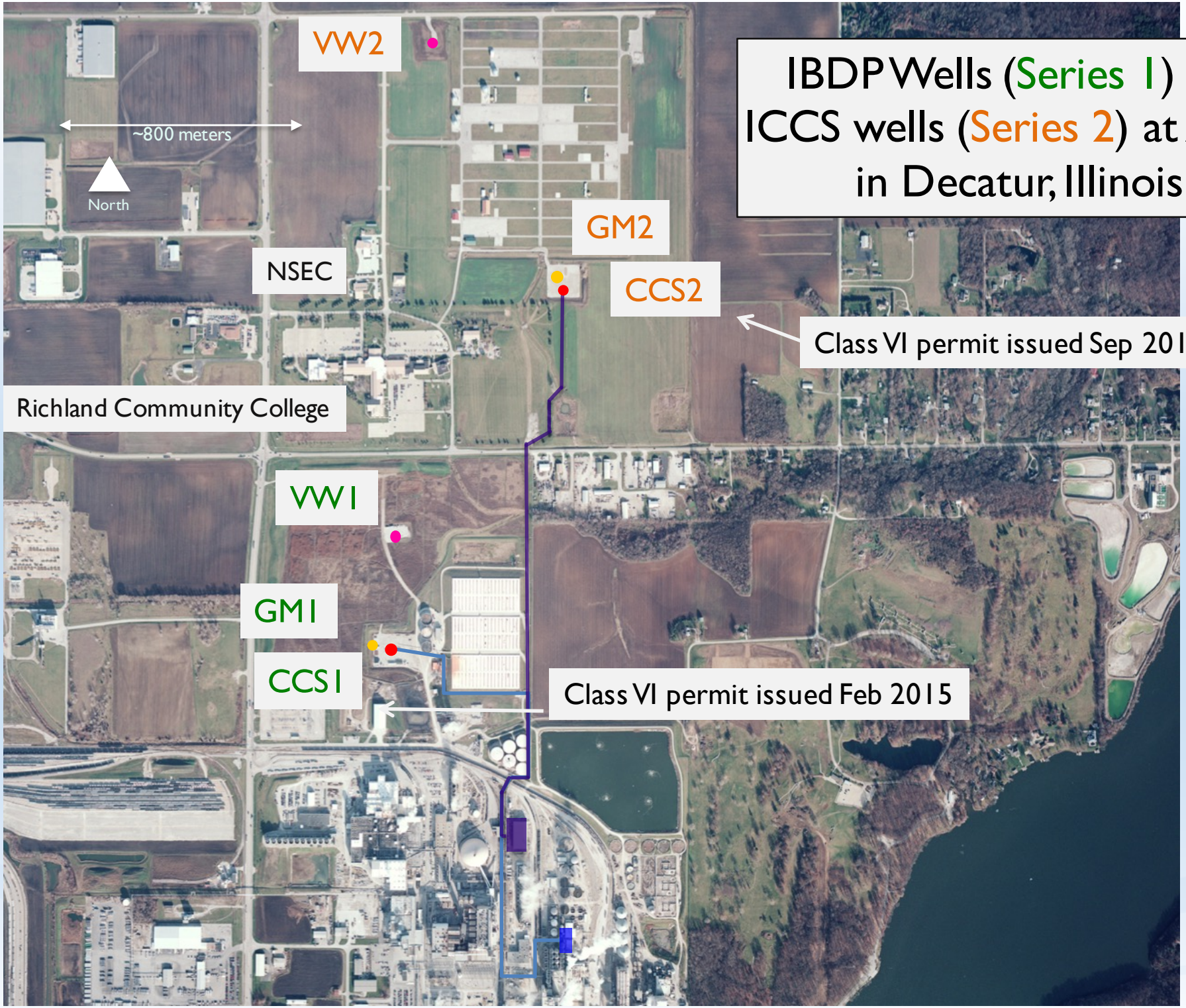
- Status: Post-injection monitoring

Illinois Industrial CCS Project

- Industrial-scale

- Volume: 5 million tonnes
- Injection period: 3 years
- Injection rate: 3,000 tons/d
- Compression capacity: 2,200 tonnes/day

- Status: Pre-injection monitoring



IBDP Wells (Series 1) and ICCS wells (Series 2) at ADM in Decatur, Illinois

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