Midwest Geological Sequestration Consortium

Carbon Storage from Biofuels at IBDP: A Progressive Success Story in Technology Innovation, Partnerships, and Collaboration

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ILLINOIS

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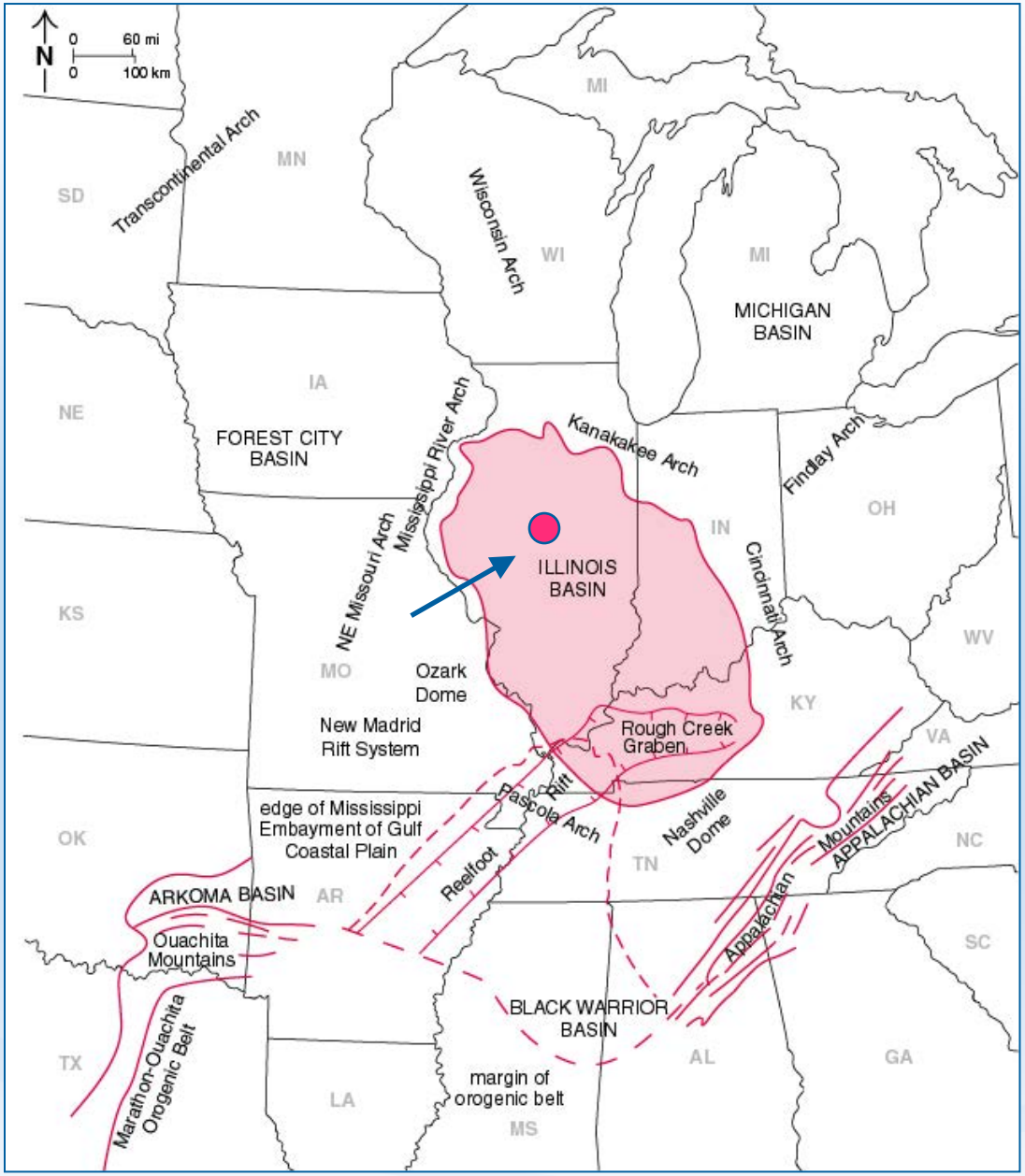
MGSC Path to Technology Innovation, Partnerships, and Collaboration

- Building CCUS Foundations
- Addressing Questions
- Meeting Challenges
- Deploying Industrial-scale CCUS
- Learning from Experience
- Building Capacity
- Taking the Next Steps

Image: Carbon Capture Project co2captureproject.org

CCUS in the Illinois Basin

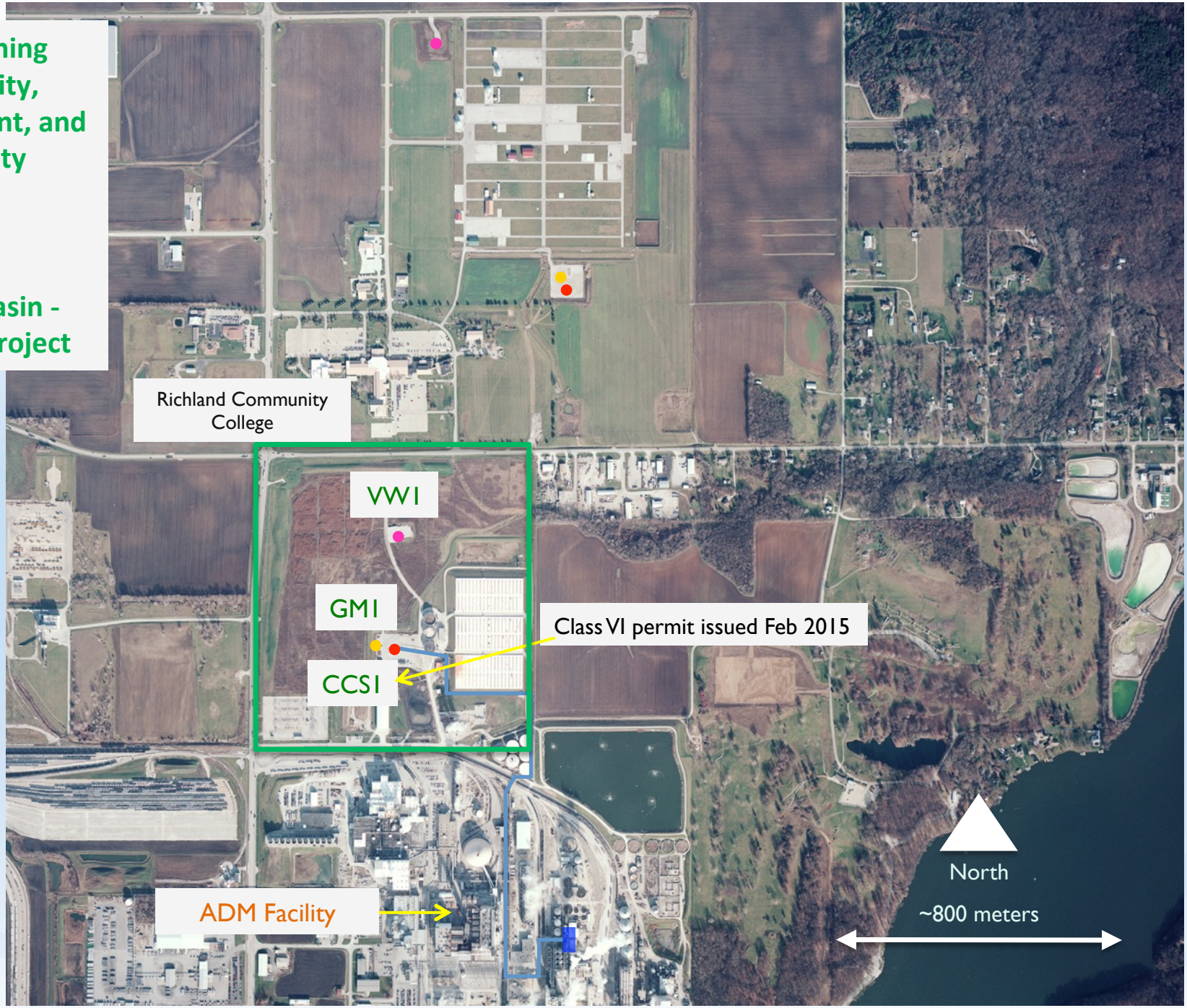


A collaboration of the Midwest Geological Sequestration Consortium, the Archer Daniels Midland Company (ADM), Schlumberger Carbon Services, and other subcontractors to inject 1 million metric tons of anthropogenic carbon dioxide at a depth of ~2,100 m to test geological carbon sequestration in a saline reservoir at a site in Decatur, IL

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

Establishing Injectivity, Containment, and Capacity

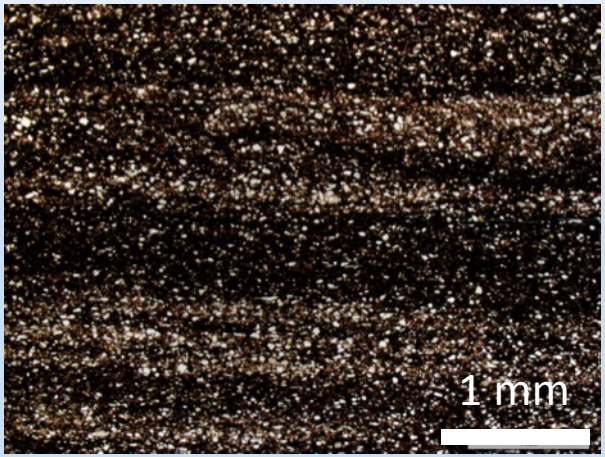
Illinois Basin - Decatur Project

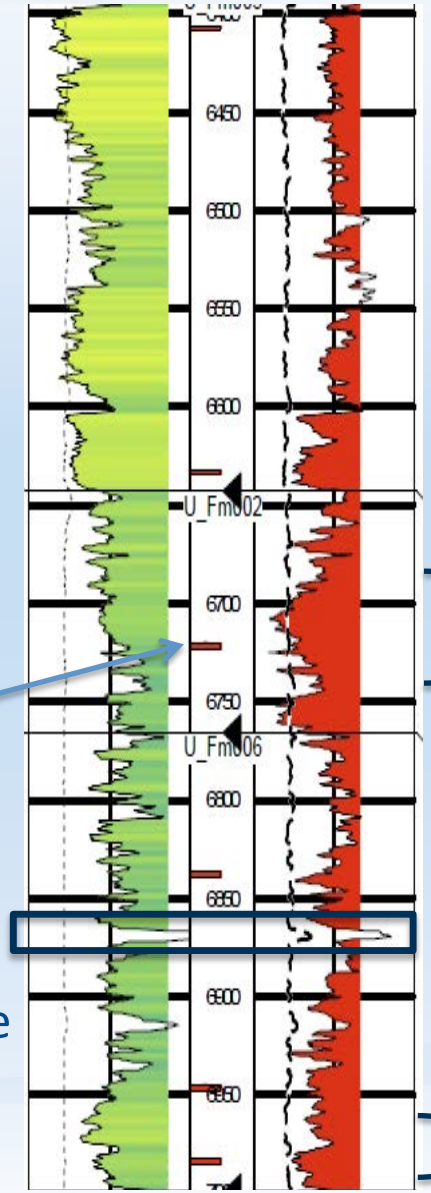


Addressing Questions

Mudstone Baffle Between Injection Zones

10 cm





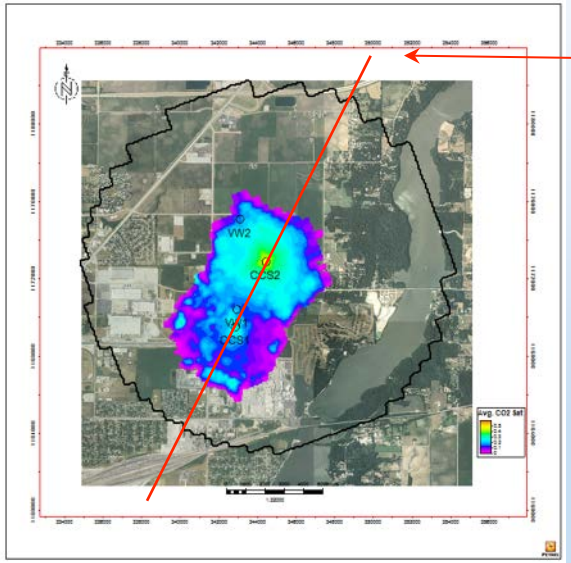
6,863-6,863.25 (2,092 m)

Porosity: 1.5%

K_v: <0.01 mD

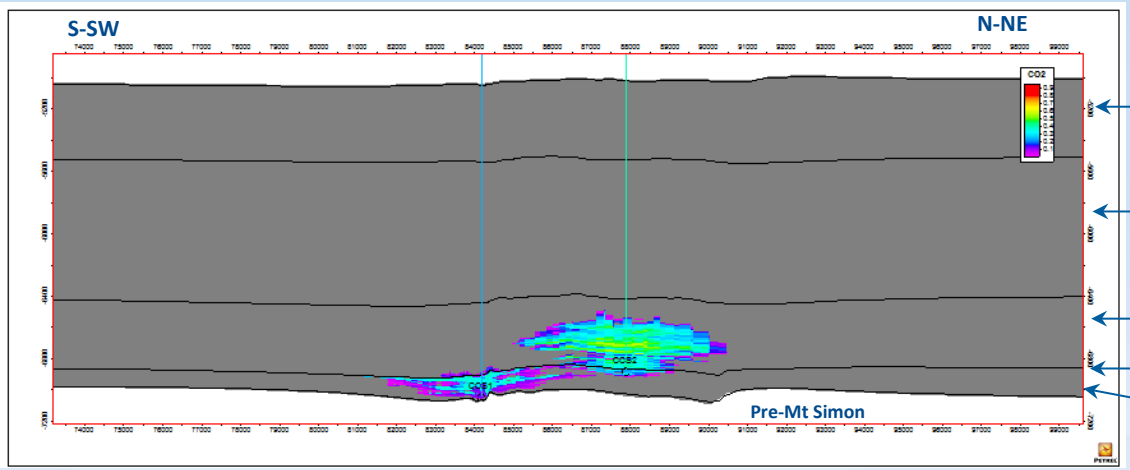
K_h: 4.13 mD in siltstone laminae

Extent of Plume & Saturation Cross Section
January 1, 2020 (year 8, end of CCS2 injection)



Cross Section Orientation

$DP_{if} \geq 86$ psi
$SCO_2 \geq 1.0\%$



Eau Claire

Mt Simon C, D, E

Mt Simon A, B

Mudstone

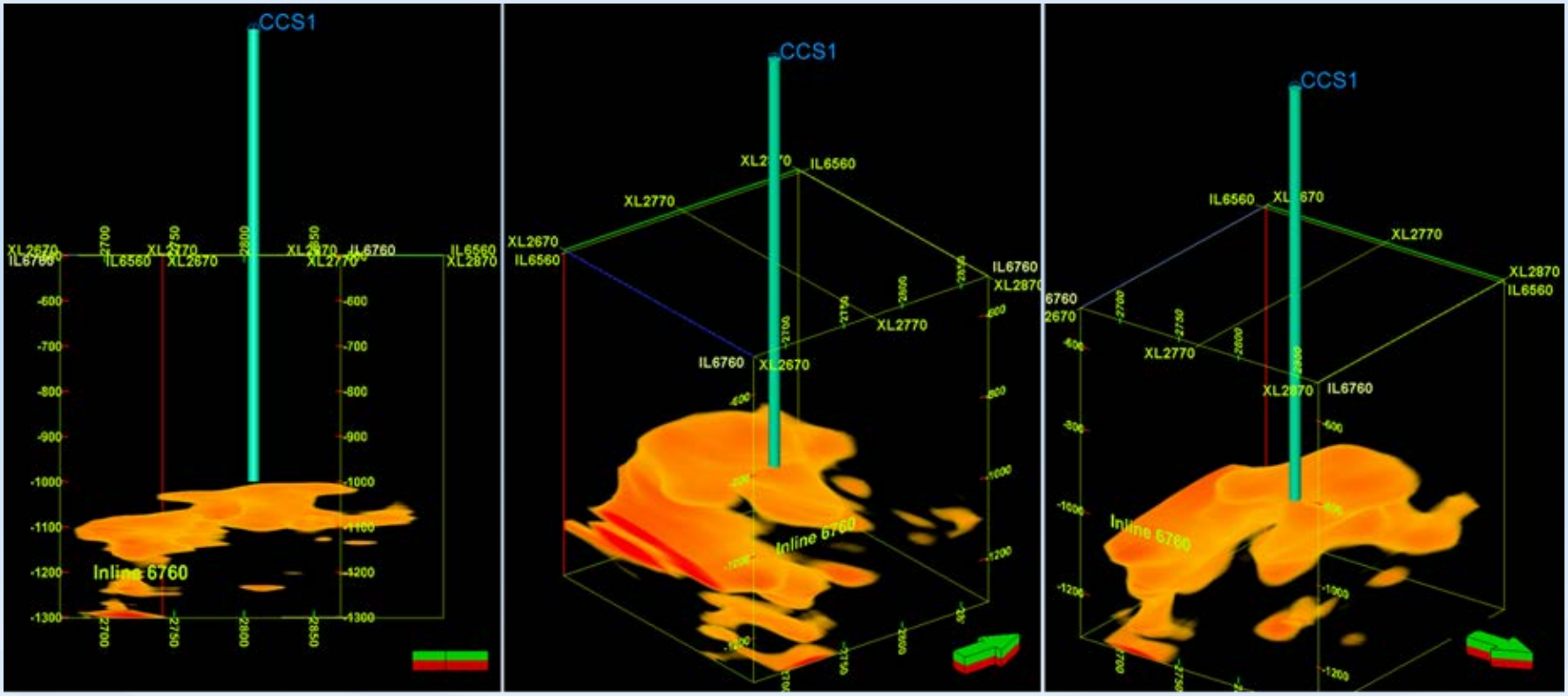
Lower Mt Simon A

Qualitative Time-Lapse Attributes: Inferring Seismic Detection Limit with Saturated Thickness

Predictability

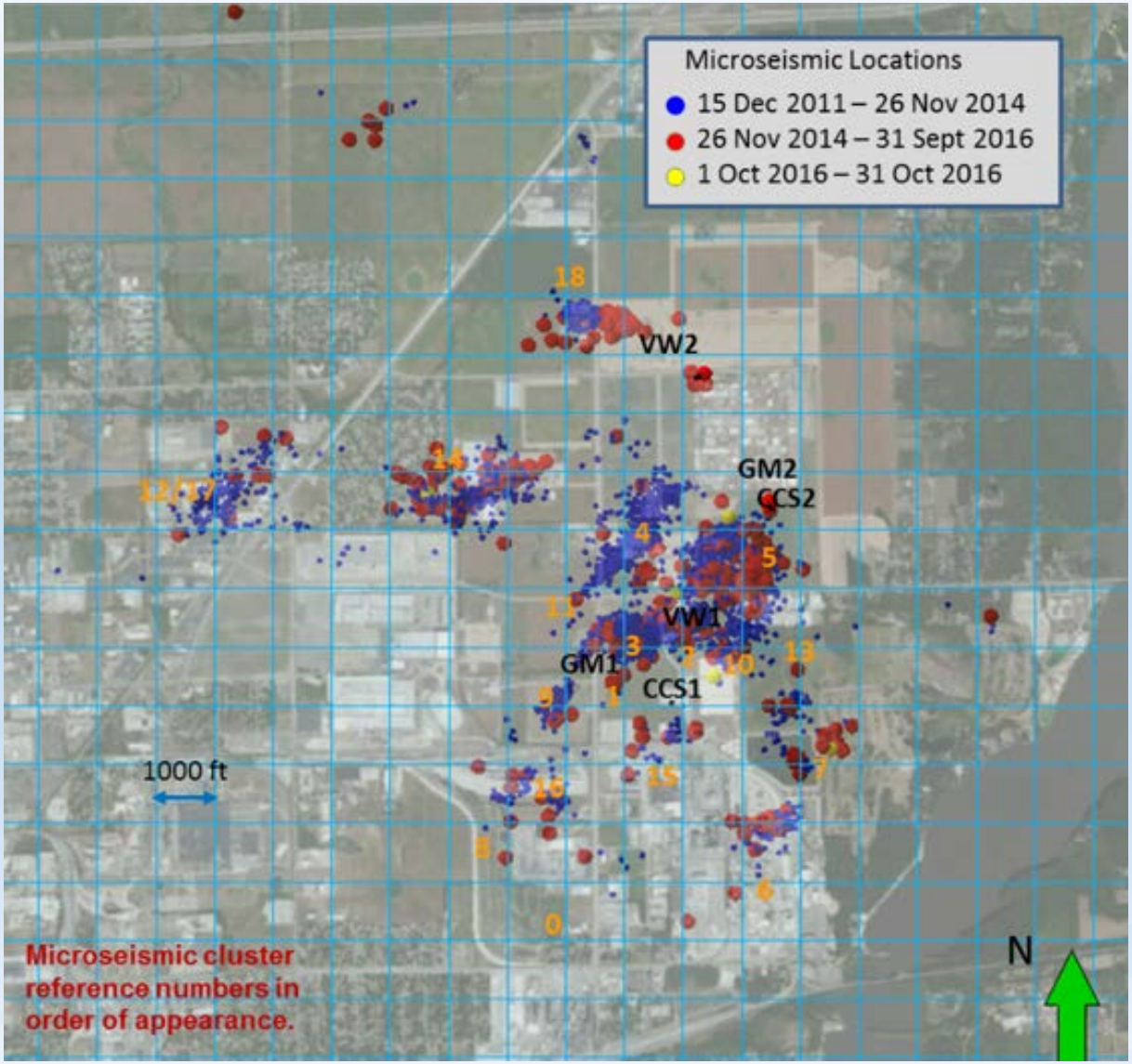
Normalized Root Mean Square

Non Rigid Matching

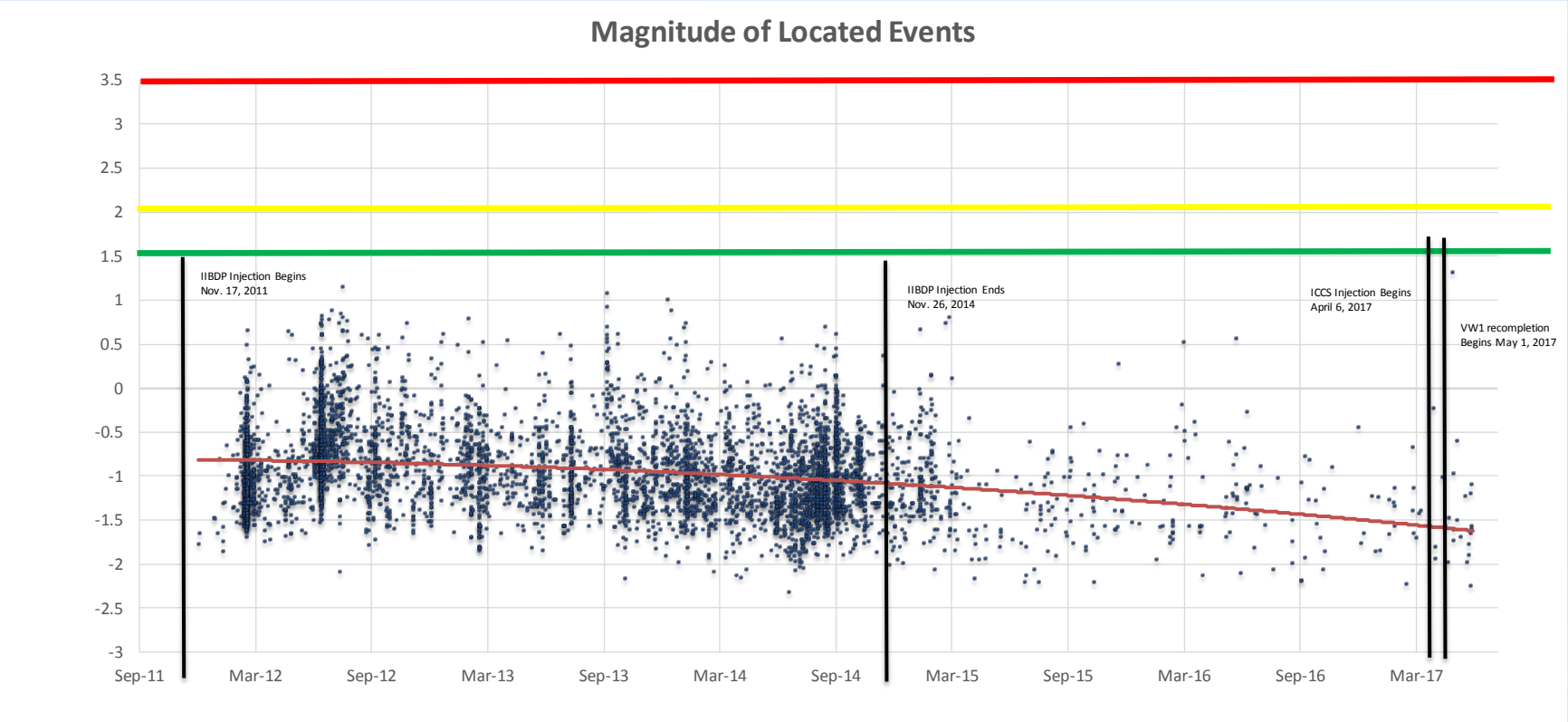


Microseismic Activity at the Illinois Basin – Decatur Project

- Observed Microseismicity associated with injection
- Location critical to understanding reservoir response
- Original correlation between cluster development and pressure front under examination
- ICCS created stoplight map to mitigate potential associated risks from felt events



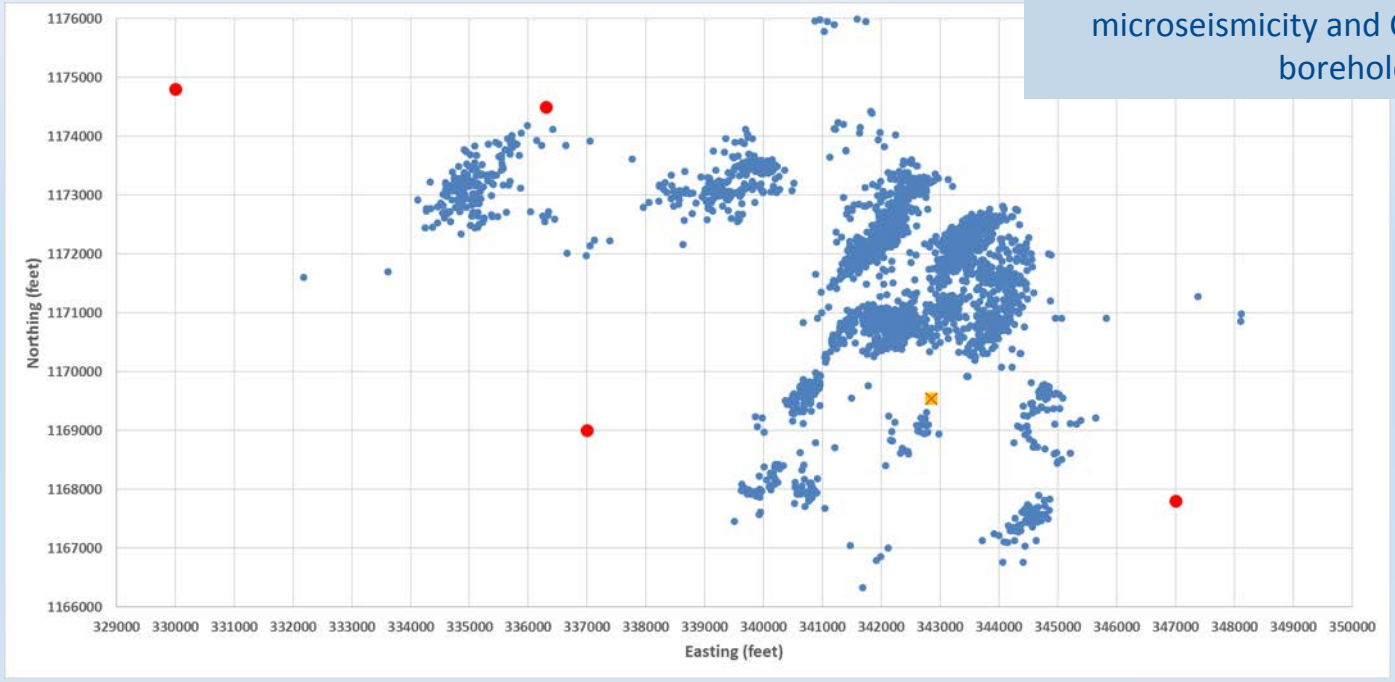
Microseismicity Time and Magnitude Related to Injection and Post-injection Activity



Collaboration between US (ISGS and BEG) and Norway (NORSAR and SINTEF)

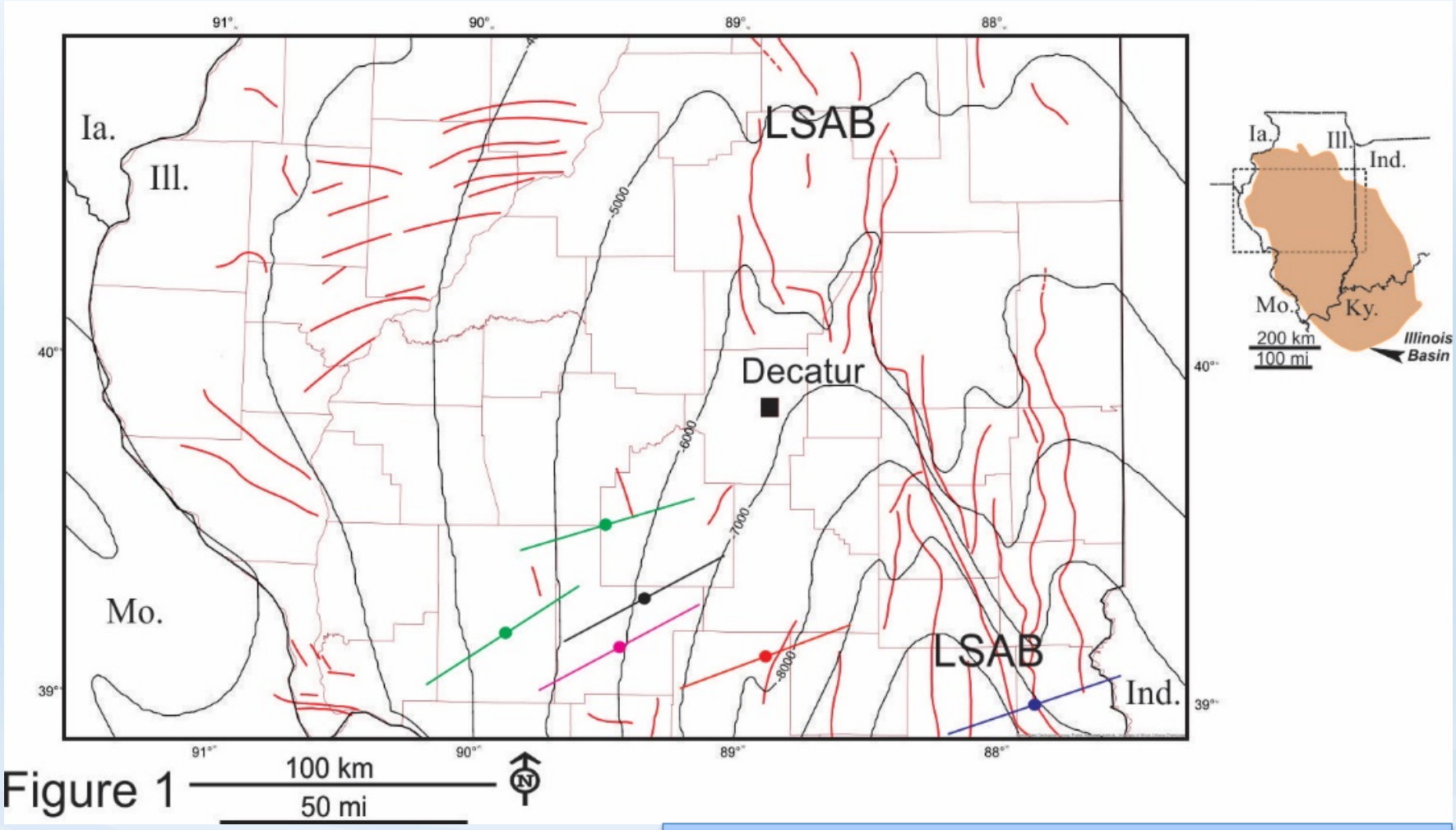
Collaboration between US and Norway: Combining passive and active seismic monitoring

Boreholes placed in glacial materials for this project in relation to recorded microseismicity and CCS1 injection borehole



Characterize Glacial overburden for Compressive and Shear Wave Velocities by placing 4 boreholes near surface seismic stations.

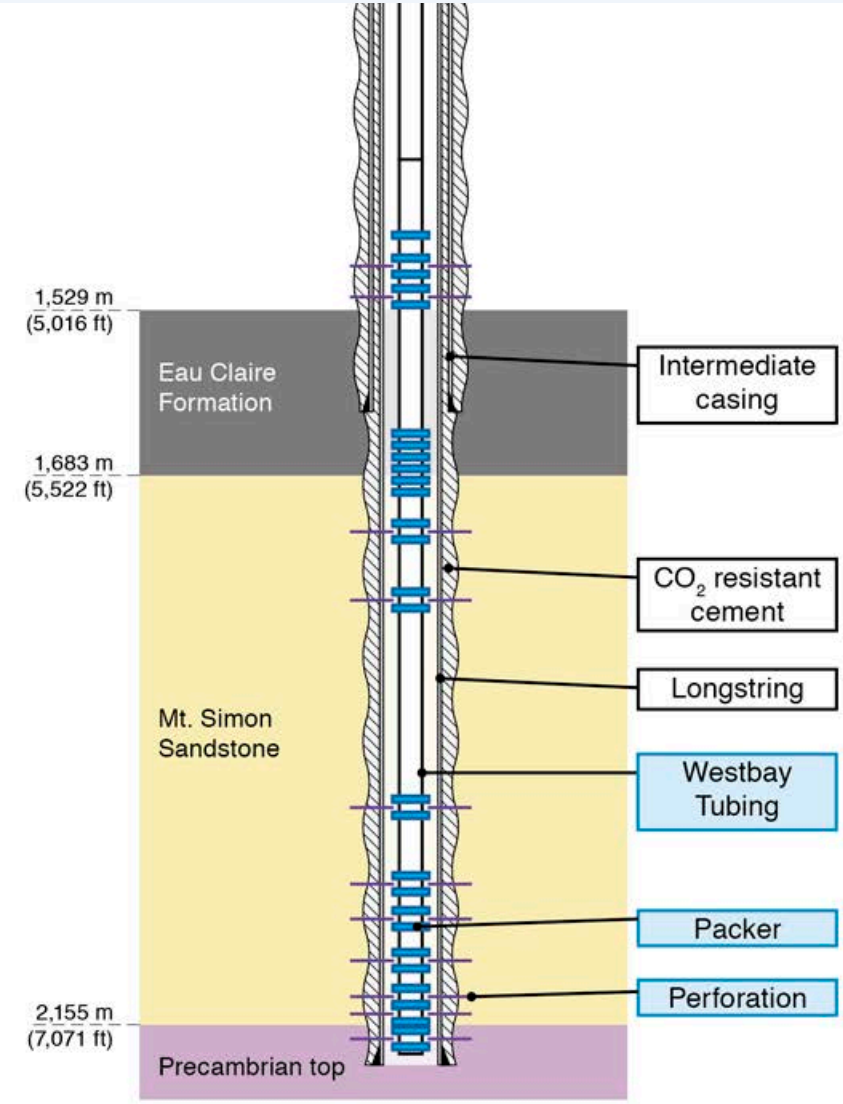
Visualizing Precambrian Basement Tectonics beneath IBDP

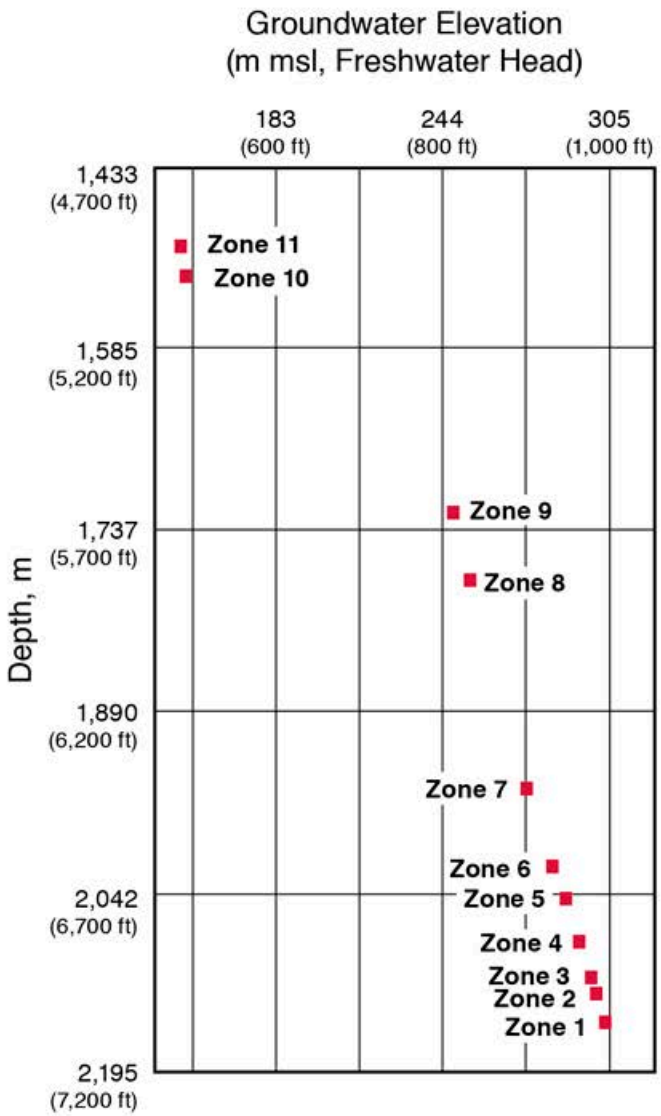


General location map for central Illinois Basin (USA) centered over IBDP study area, Decatur, Illinois.

Meeting Challenges

VW1 Westbay Completion





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

Deploying Industrial-scale CCUS

Multiple Projects Build Framework for CCUS Research and Commercialization

Illinois Basin - Decatur Project

Illinois Industrial Sources CCS

Intelligent Monitoring Systems

BEST - Brine Extraction

Current CCUS Projects 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

Contribution:

- Geologic and Social Site Characterization
- Reservoir Modeling and Risk Assessment
- MVA Development and Engineering Design
- Stakeholder Engagement

Status:

- Post-injection monitoring ends April 2020

Illinois Industrial CCS Project

- Industrial-scale demonstration
- Volume: up to 5 million tonnes
- Injection period: 3 years (or longer)
- Injection rate: 3,000 tons/d
- Compression capacity: 2,200 tonnes/day

Contribution:

- Commercial-scale up surface and subsurface
- Multi-plume modeling
- Class VI permitting
- Regulatory MVA
- Education programs

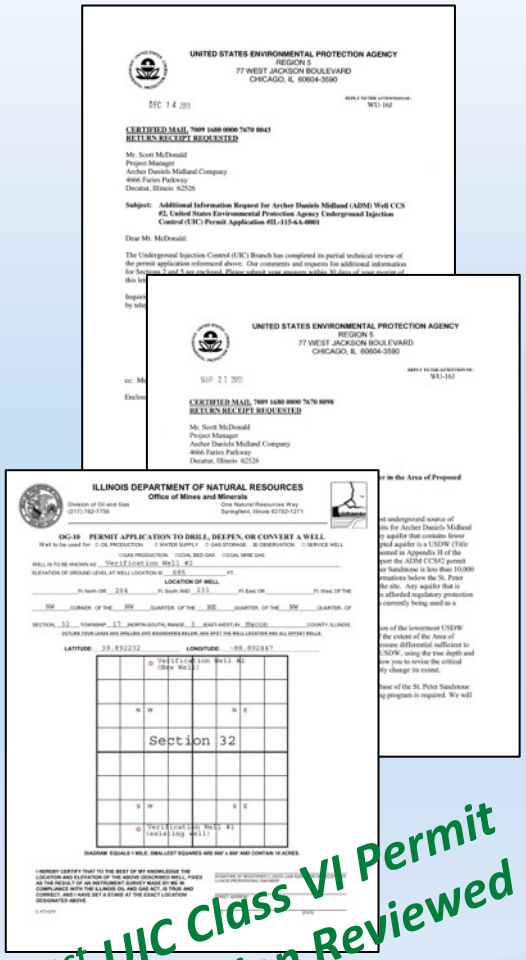
Status:

- Injection Began April 7, 2017

Permitting of wells for two projects linked

- Permitting has been rate-limiting step for both projects
- Permits for IBDP Post-injection Site Care and ICCS injection + Post-injection tied together
- Project expansion due to delay in injection start

- Example:
  - ICCS application submitted: 25 Jul 2011
  - Draft permit issued: 4 Apr 2014
  - Public hearing conducted: 21 May 2014
  - Public comment period ended: 31 May 2014
  - Final permit issued 28 Dec 2014
  - Permission to inject: 7 Apr 2017 (825,000 tonnes)



1st UIC Class VI Permit Application Reviewed by the USEPA

IBDP Environmental Monitoring Framework

Near Surface			Deep Subsurface	
Atmos.	**Soil and vadose zone**	**Shallow ground water**	**Above seal**	**Injection zone**
Eddy covariance Meteorological conditions Ambient CO_2 Tunable diode laser for CO_2	CIR aerial imagery InSAR and GPS Soil gases Soil CO_2 flux Tunable diode laser for CO_2	Geophysical surveys Geochemical sampling P/T monitoring	Geophysical surveys Geochemical sampling P/T monitoring	Geophysical surveys Geochemical sampling P/T monitoring

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Environmental Monitoring Framework

Near Surface

Atmos.

- Eddy covariance
- Meteorological conditions
- Ambient CO_2
- Tunable diode laser for CO_2

Soil and vadose zone

- CIR aerial imagery
- InSAR and GPS
- Soil gases
- Soil CO_2 flux
- Tunable diode laser for CO_2

Deep Subsurface

Shallow ground water

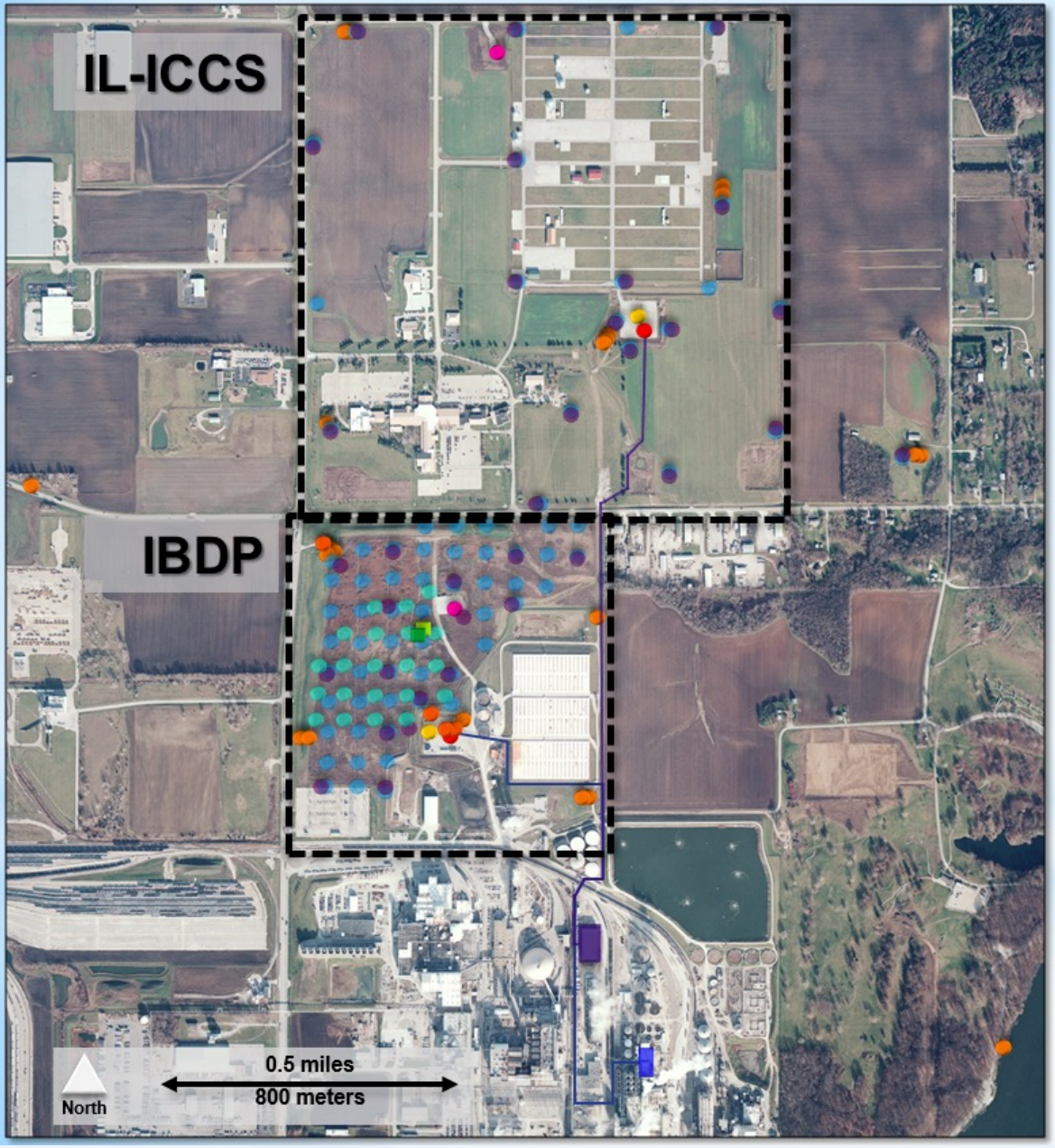
- Geophysical surveys
- Geochemical sampling
- P/T monitoring

Above seal

- Geophysical surveys
- Geochemical sampling
- P/T monitoring

Injection zone

- Geophysical surveys
- Geochemical sampling
- P/T monitoring



Monitoring Summary

- Injection wells (2)
- Verification wells (2)
- Geophysical wells (2)
- Compliance wells (4)
- Research wells (24)
- Soil gas points (35)
- Soil flux points (145)
- Eddy covariance station (1)
- Continuous GPS station (1)
- InSAR artificial reflectors (21)

IBDP and IL-ICCS Installations

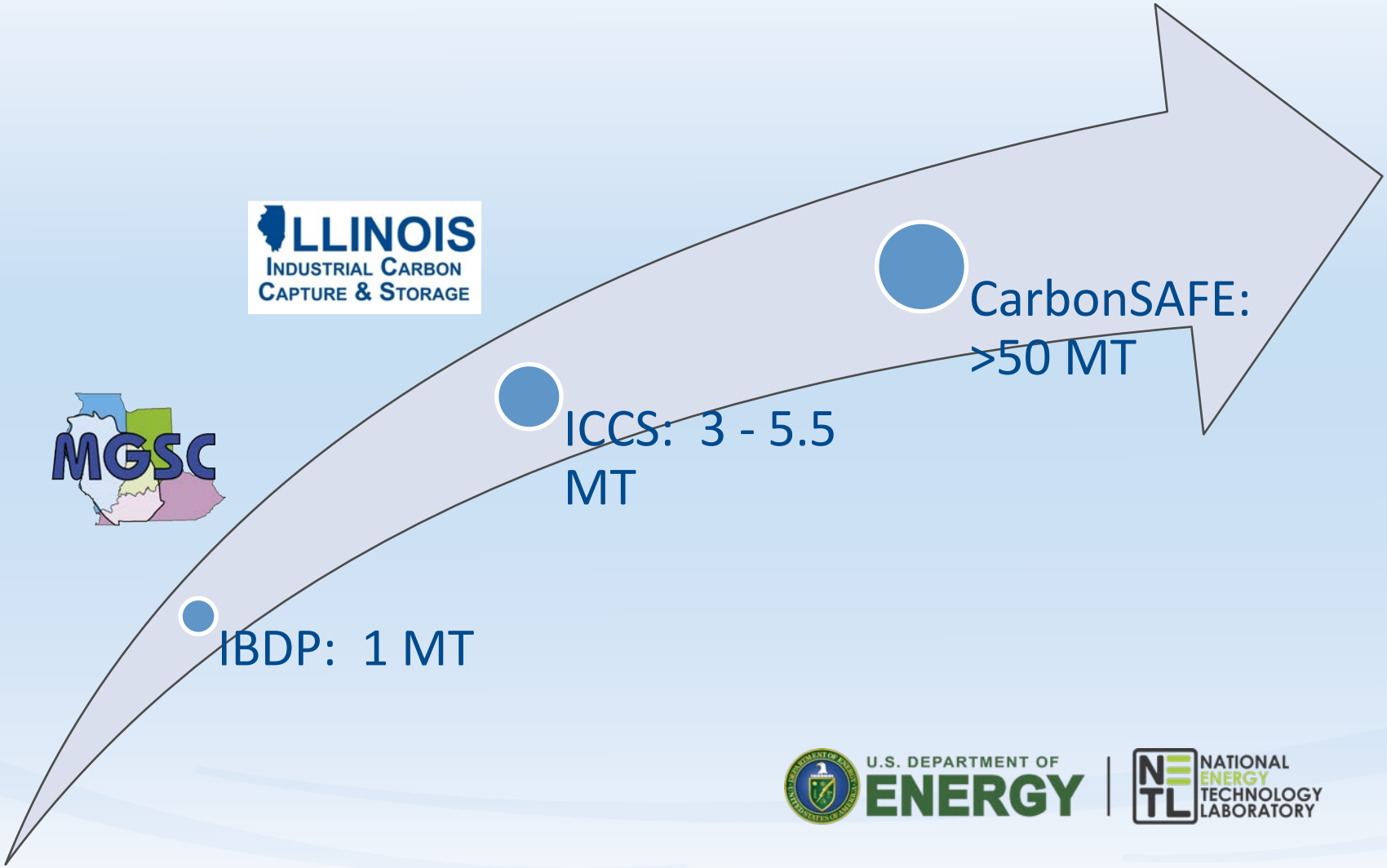
- IBDP: Comprehensive research- and risk-based program
- IL-ICCS: targeted, regulatory focused program based on IBDP
  - Note: decrease in installation density
- Monitoring perspectives:
  - Programs should be risk based
  - Overall project de-risking may require a blend of
    - Research Goals
    - Regulatory Requirements
    - Commercial Drivers
  - Technique Scalability needs to be considered

Illinois Industrial Sources CCS

- Operational Injection April 7, 2017
- Step rate increase of CO_2 to full injection
- Pressure in nearby wells
- 500,000 tonnes injected as of 12/27/18
- Eligible for 45Q
- Limited microseismic activity

Learning from Experience

Illinois Basin Industrial CCS Progression



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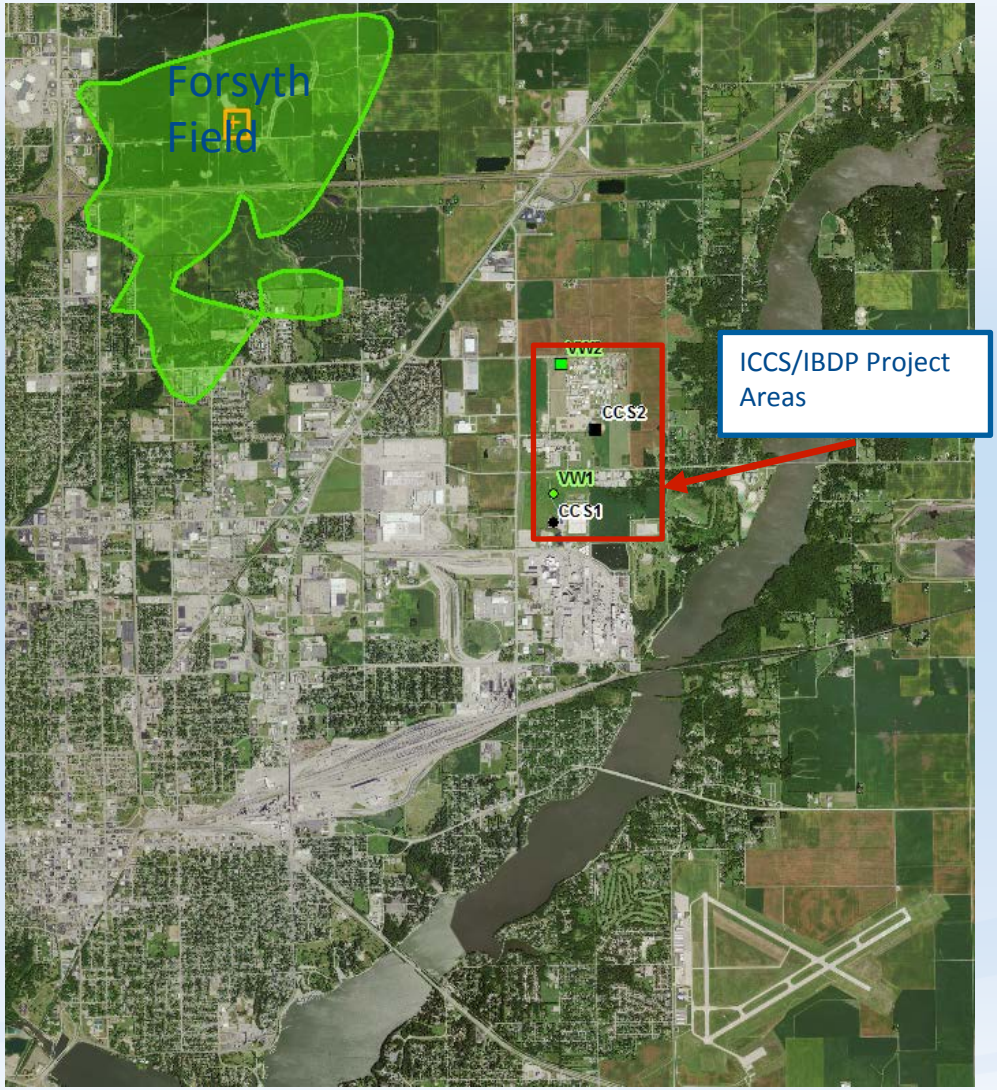
CarbonSAFE Illinois – East Basin and Macon County

- Pre-feasibility East Basin
- Feasibility Decatur

- 50 million tonne Storage Complex
- Address gap in development knowledge for large-scale carbon storage
- Improve storage capacity estimates (± 30%) for industry investment decisions
- Validate NRAP Toolkits for storage permanence and storage efficiency
- Contribute to best practice manuals to inform future commercialization efforts



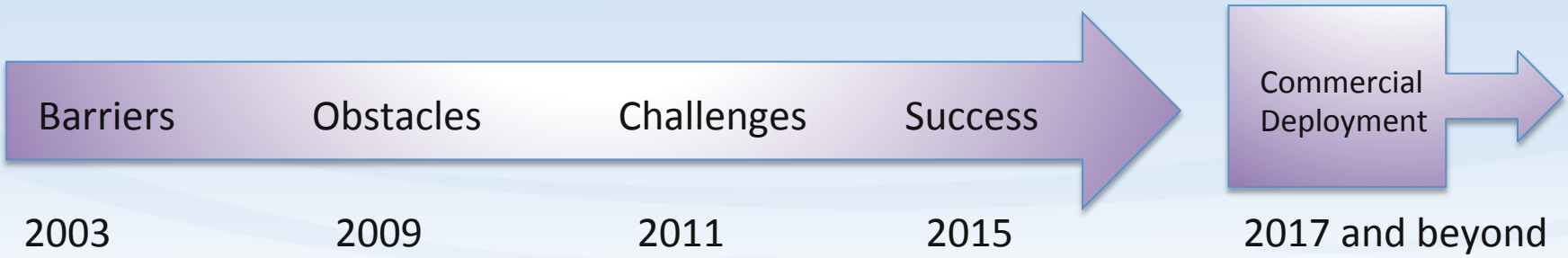
IBDP by the numbers:

- A million tonnes stored from **biofuels** and…
- More than **5,000 meters** of drilled wells
- More than **245 meters** of collected core
- 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 **900 visitors from 30 countries** have been to IBDP
- More than **100 people at least 10 organizations** have worked together to make this project a success

XSEDE is an NSF-sponsored supercomputer network

What We've Learned:

- Carbon capture and storage from biofuel sources in deep saline reservoirs can be conducted safely
- Research and scale-up demonstration projects can lead directly to industrial-scale or commercial-scale projects
- The Mt. Simon Sandstone is a viable and important deep saline storage resource for the US
- Establishment of an MVA baseline is critical to characterize site and reduce project risk, but needs to be revisited on a regular basis
- Permitting can be time intensive and should not be underestimated as a potential project risk
- Economy of scale learnings essential to commercial CCS deployment



The Future

MGSC and IBDP Future Steps

- Compliance phase of post-injection monitoring – April 2020 (tied to start of ADM Industrial CCS Sources project)
- Completion of science activities
- Full integration and completion of dynamic model for use on additional regional projects
- Basin-scale modeling conducted with heterogeneous reservoir characteristics
- Microseismic research review response
- Knowledge sharing and capacity building
- Publication of IBDP technical papers
- Publication of IBDP project experience and learnings book

Acknowledgements

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