An Assessment of Geological Sequestration Options in the Illinois Basin-Phase II and III

(FC26-05NT42588)

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National Energy Technology Laboratory

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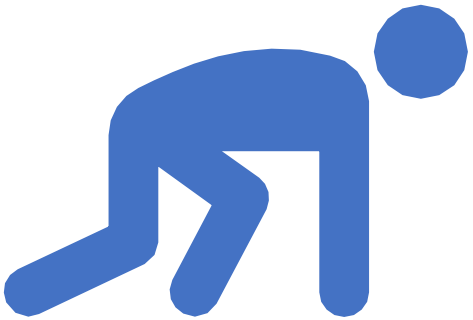
The MGSC is Nearing the Finish Line



"CCS – it's a marathon, not a sprint"

- Accomplishments
- Progress
- Learnings
- Final steps
- Acknowledgments

Safe and Effective storage: The pieces Have come together

Barriers (2003)

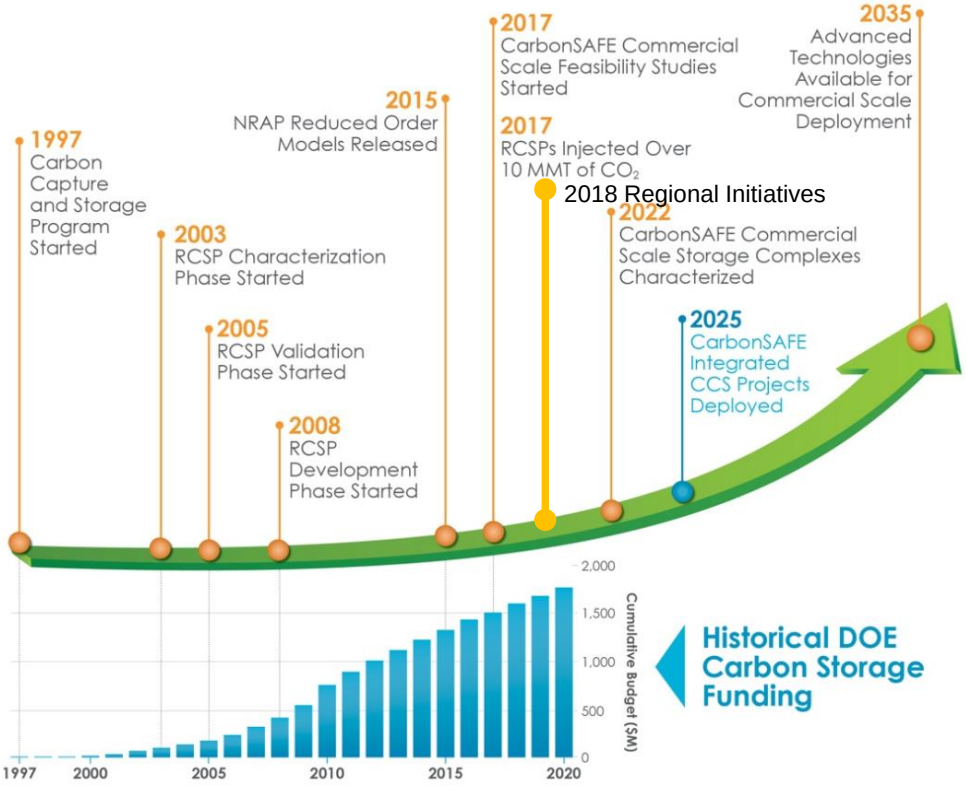
Obstacles (2009)

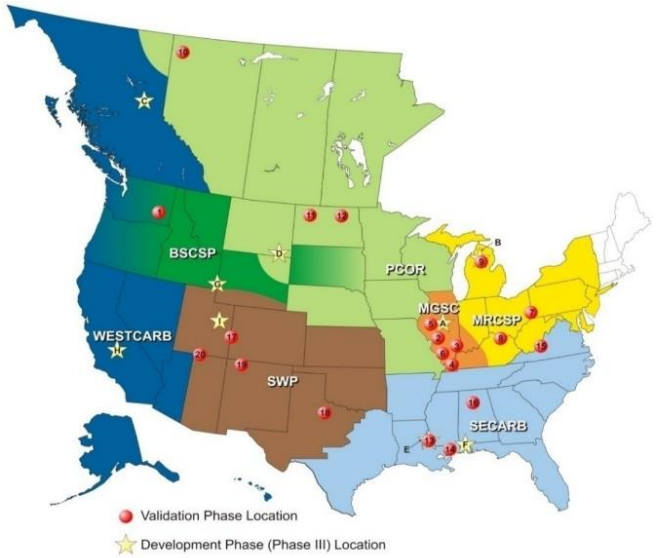
Challenges (2011)

Successes (2015)

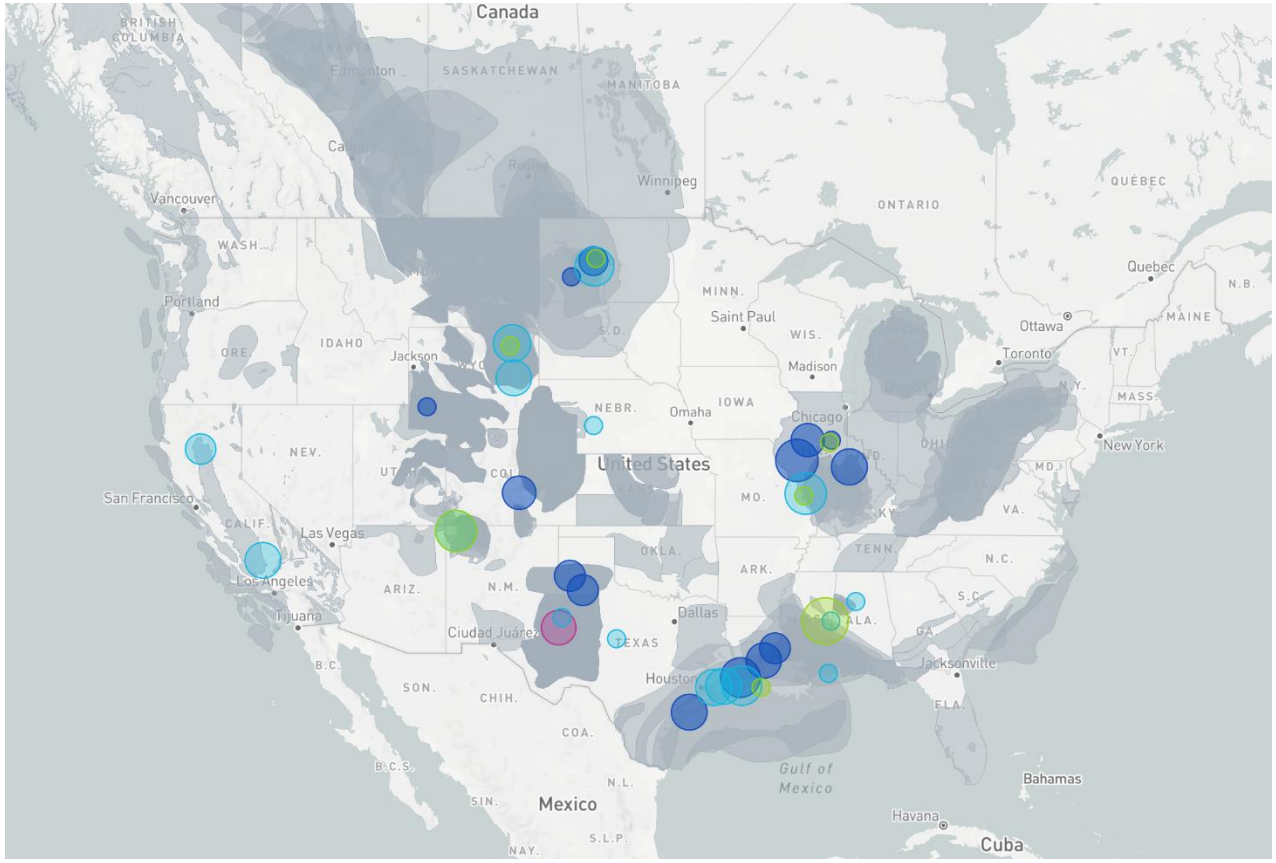
Commercial Deployments (2017 and beyond)

Exhibit 2-1. Cumulative investment and milestones toward achieving technology readiness for widespread commercial-scale deployment





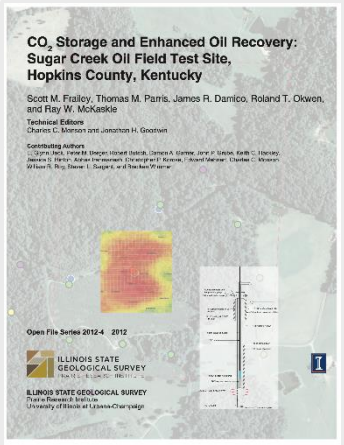
Projects and Prospects Align with Partnerships

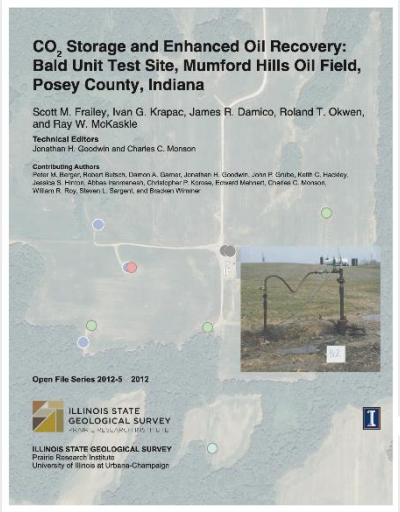


https://www.catf.us/2020/07/ccus-interactive-map/

MGSC Phase II Accomplishments

- Phase II
  - EOR – Loudon Huff n' Puff
  - EOR – Sugar Creek
  - EOR – Mumford Hills
  - ECBM – Tanquary Farms





MGSC Phase III Accomplishments: Illinois Basin – Decatur Project

- Captured, transported, stored, and monitored 1 million tonnes of CO_2 from biofuel production in an onshore Saline Reservoir
- Executed FOAK monitoring, verification, and accounting (MVA) program
- Met and exceeded all technical and non-technical challenges
- Successful Class VI permitting
- Conducted microseismic monitoring and interpretation
- Developed International collaborations
- Laid foundations for multiple projects
- Build international, national, and regional capacity
- Stakeholder engagement strategy built trusted relationships
- Created comprehensive data set

IBDP by the numbers (IBDP + ICCS):

- 3+ million tonnes CO_2 stored from **biofuels**
- 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 **60,000 analyses**
- For basin-scale modeling, we will use **1,020,000 CPU-hours** of XSEDE supercomputing resources.
- More than **1,700 visitors from 29 countries** have been to IBDP and ICCS
- More than **100 people from at least 10 organizations** have worked together to make these projects a success

Project Stakeholder Engagement

1. Conduct projects to demonstrate safety and address gaps in knowledge or experience.
2. Engage local stakeholders, regulators, and project developers.
3. Provide proof of concept.

Policy Stakeholder Engagement

1. Create effective legal and regulatory mechanisms and policy to support widespread deployment of CCUS.
2. Engage lawmakers, coalitions, policymakers, and industry.
3. Set policy to incentivize CCUS actions and development.
4. Identify common ground and potential opposition points.

Public Stakeholder Engagement

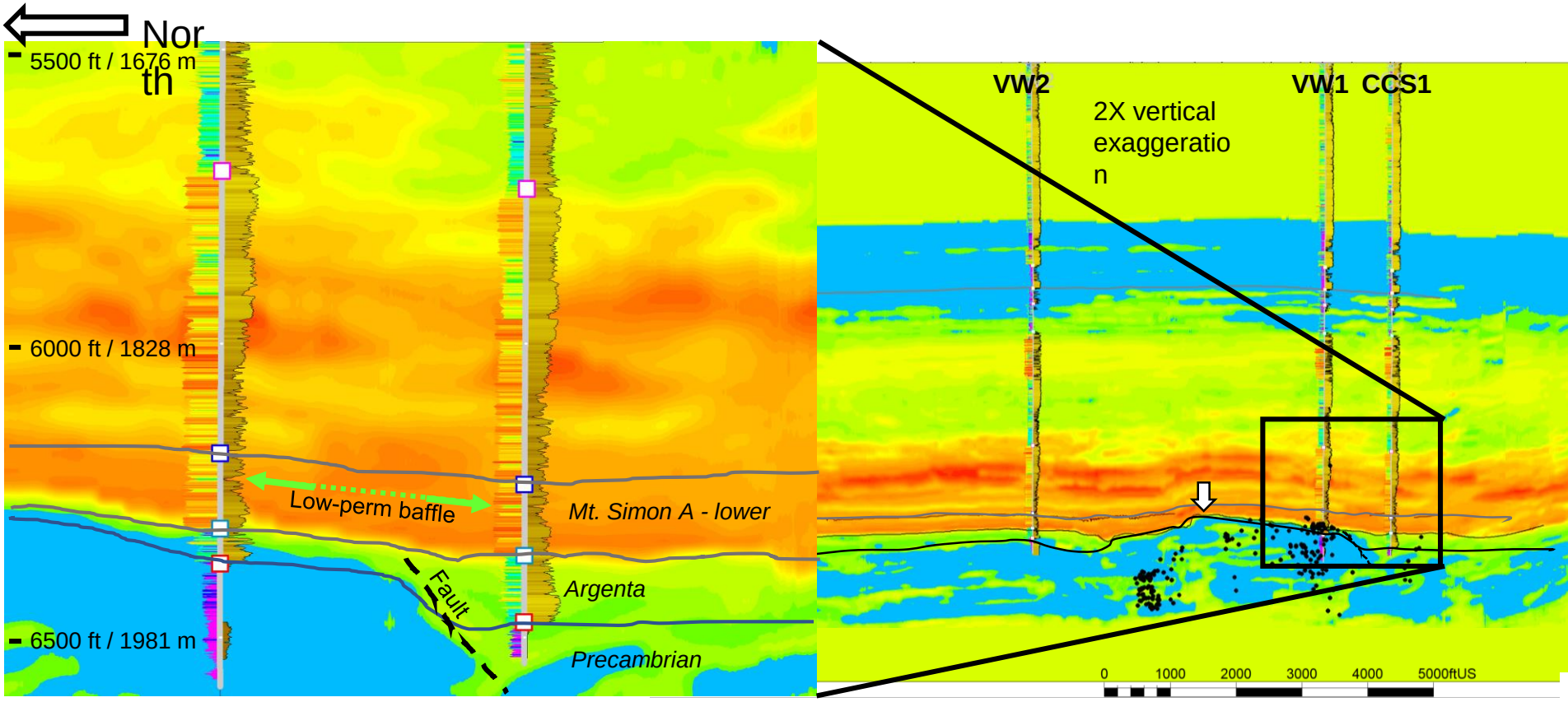
1. Create public engagement programs and opportunities.
2. Engage the public to build trust in carbon management.
3. Increase understanding and support.
4. Connect with the "big picture"— economy, climate creation of jobs.

Social Engagement

Greenberg, 2019. Stakeholder spheres of engagement.

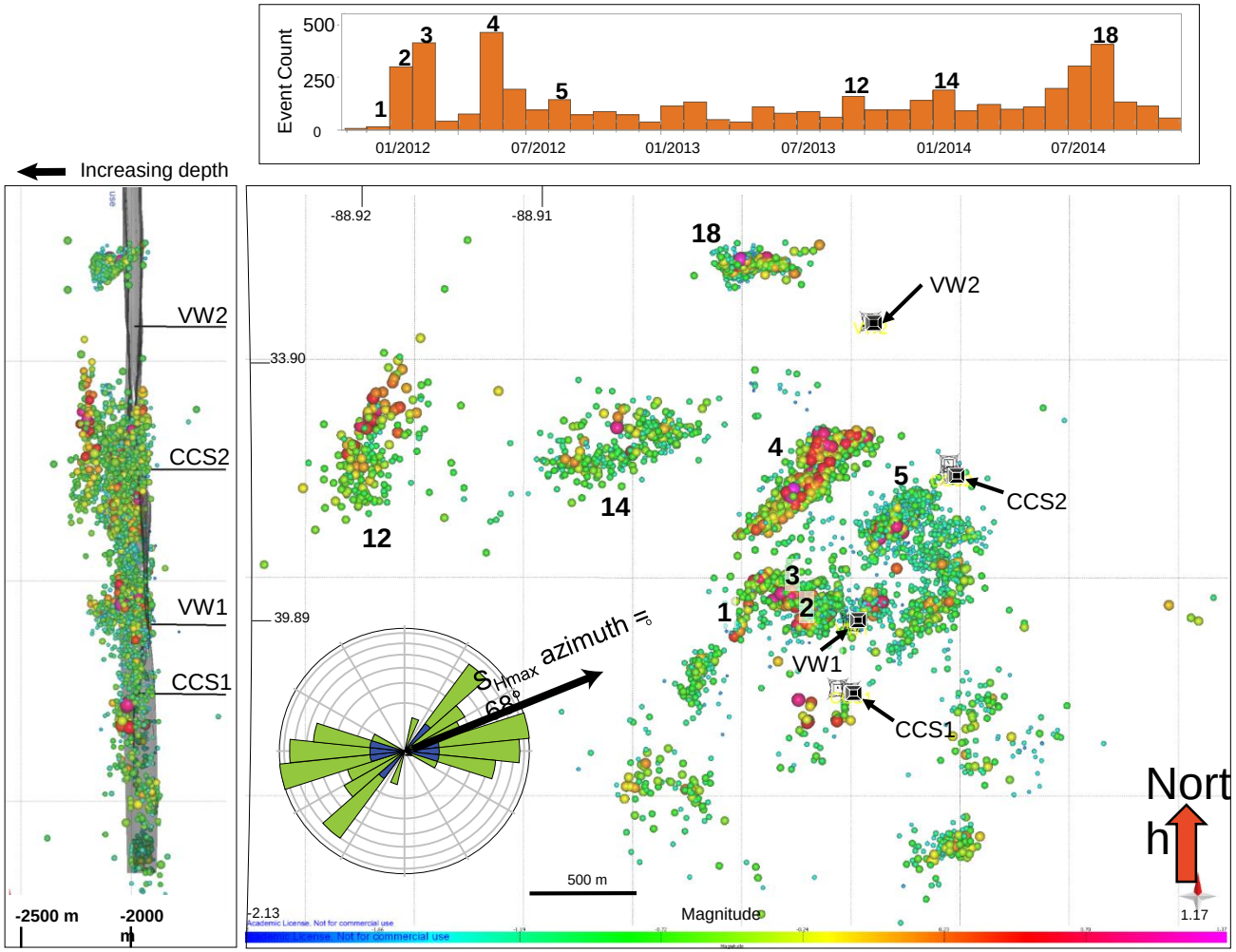
Refection Seismic Porosity Inversion

Wells and seismic events projected onto the cross section from up to 200 ft.



Event Cluster Development

- ~5000 events detected during CCS1 injection
- Depth view shows top of Precambrian
- Clusters are numbered by sequence of first occurrence
- Cluster 4 developed early – contains ~900 events
- Double-difference relocation of all located events is nearly complete

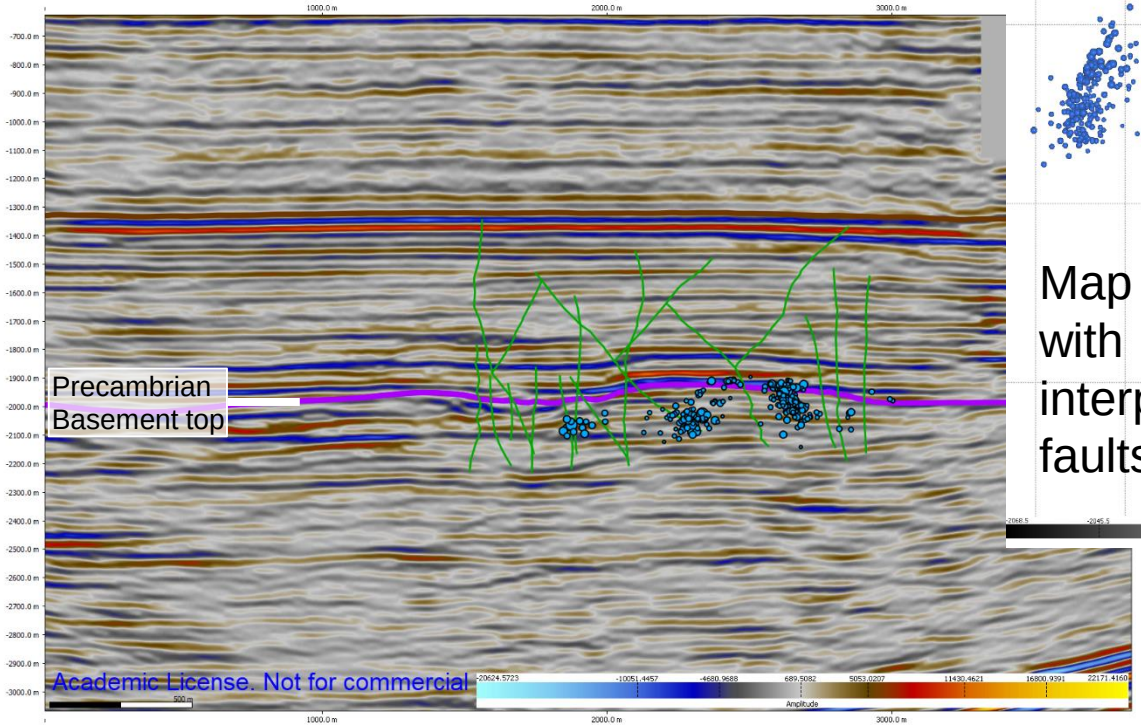


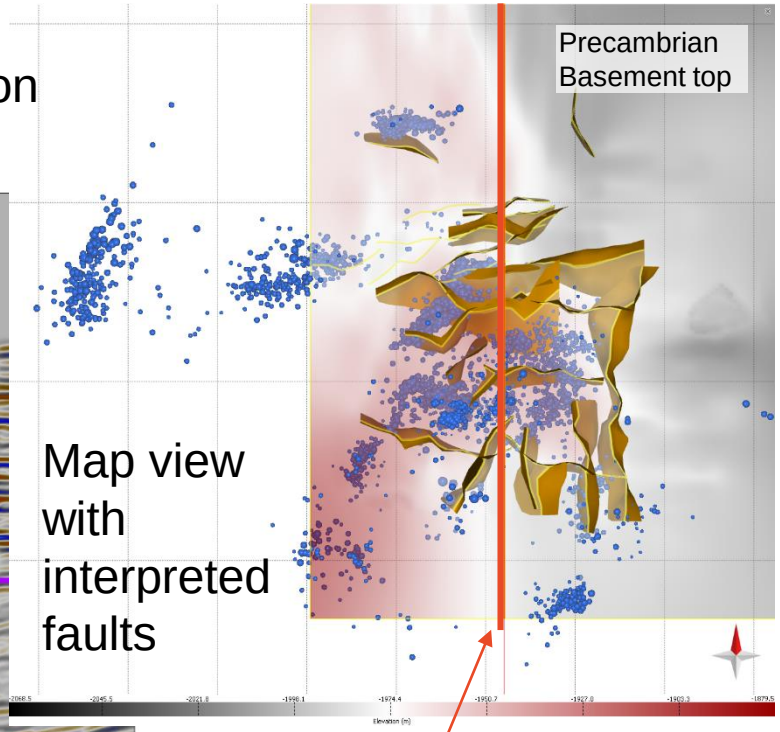
IBDP Active Seismic Depth Slice

Interpreted fault lengths range from 50 m to 1000 m

Partially coincident with microseismicity clusters, but different orientations

Largest (cluster 4) is ~ 800 in longest dimension



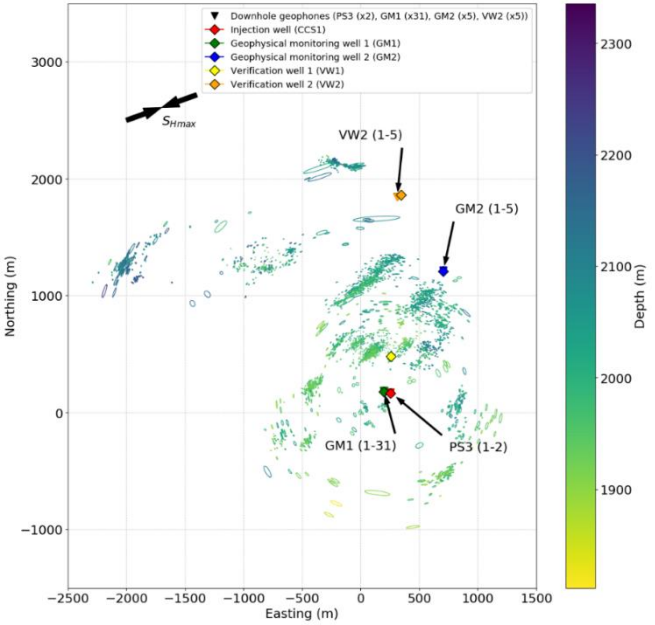


Map view with interpreted faults

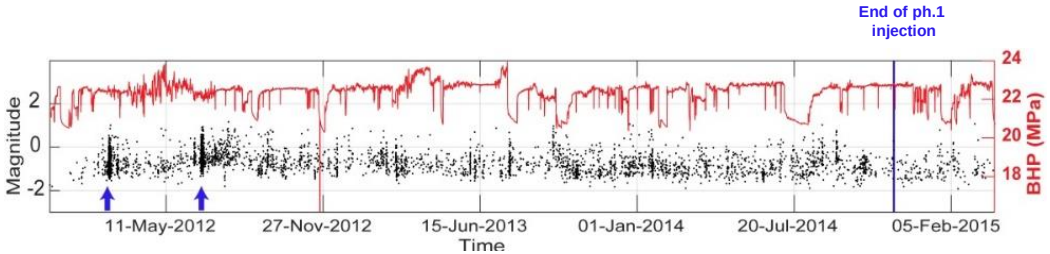
Seismic Line location

CO2CAP
US-Norway International Collaboration

- Improved understanding of individual sources
  - Double-difference event relocation catalogue including location uncertainty assessment *(Dando et al. 2020, in preparation for GJI)*
  - Focal mechanism analysis using combined surface and downhole recordings *(Langet et al. 2020, BSSA)*
- Fracture network evolution using microseismic analysis from large to fine scale



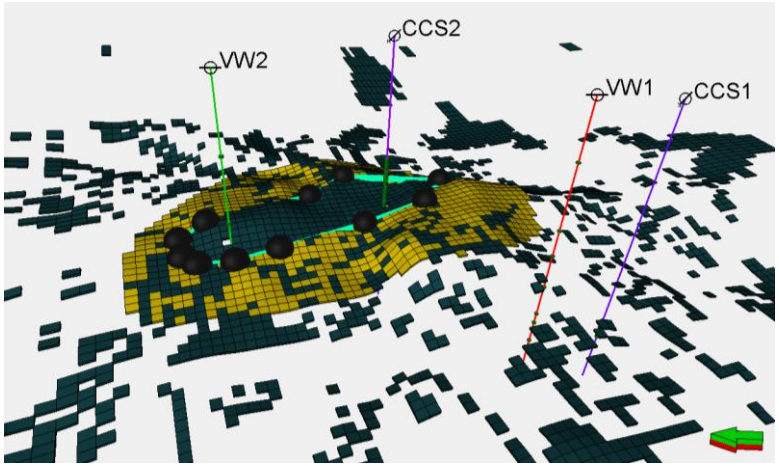
Relocations with location uncertainties

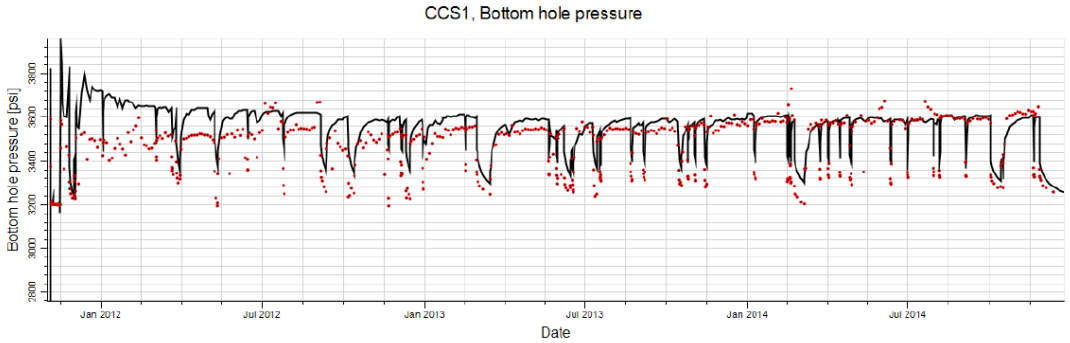


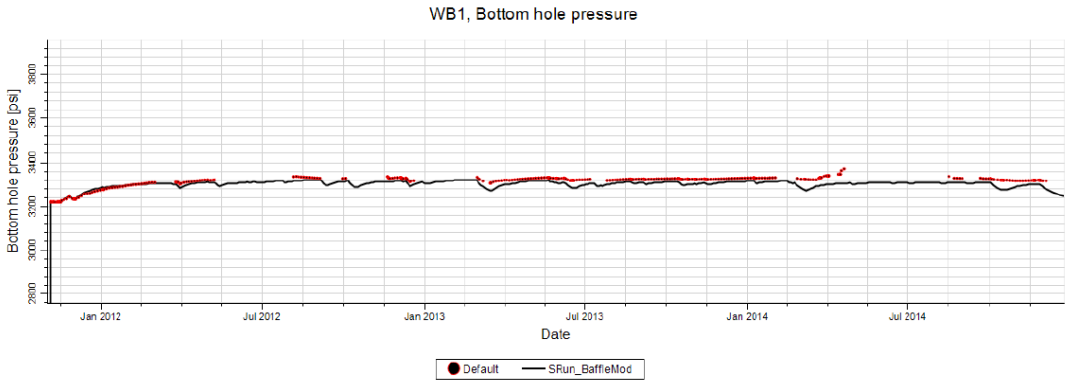
"Burst" analysis

Final IBDP Model

- Flow simulations nearly complete
- Fracture modeling properties will be incorporated to improve history match
- Geomechanical to be combined with simulation model to predict stress changes due to CO_2 injection and migration





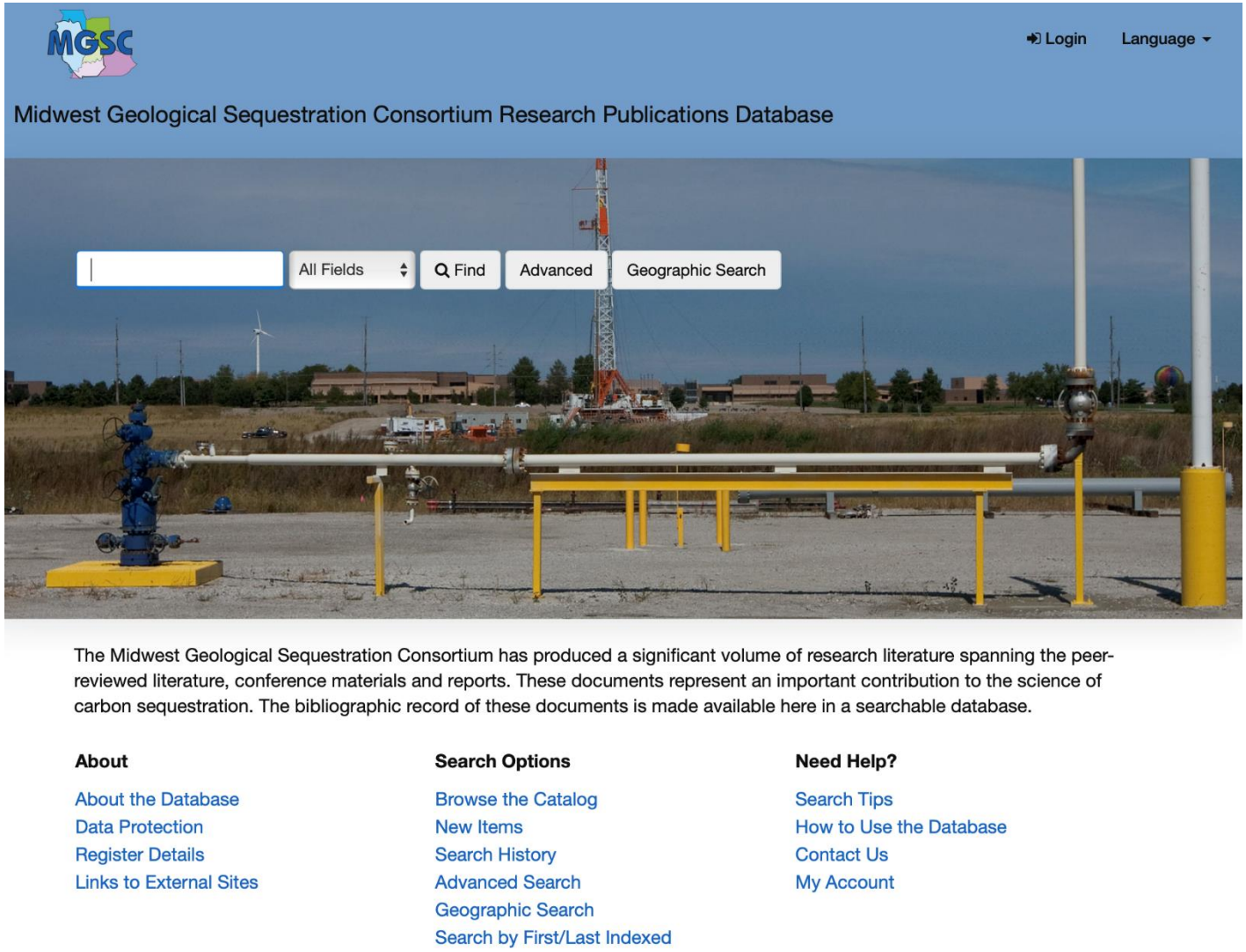


Geologic Insights Gained from IBDP and IL-ICCS

- Impactful reservoir heterogeneity occurs at km scale
- Induced seismicity in basement – similar to other locations, but
  - Small faults consistent with small seismic events
  - Hydraulic or fluid connection to basement not guaranteed
- Large uncertainties for pre-injection fault identification
  - downside: not useful to identify reactivation risk
  - upside: likely indicates lower induced seismicity risk
- Demonstration project provided advantage: pressure/stress data enabled applying learnings to subsequent well(s) to decide location and injection depth.
- Seismicity not closely tied to injection rates – the bigger impact appears to be horizontal to vertical permeability anisotropy. Vertical restriction due to stratigraphic architecture within the reservoir also inhibited pressure communication to the basement.

Lessons Drive Advancement

- Geology is critical and will always remain key factor
- Iterative scientific investigation allows for advancement and economy of scale
- Baseline environmental assessments are critical
- Unanticipated results provide insights into improvements that benefit all projects
- Incorporate technology changes into life cycle of project
- Occom's Razor applies to CCUS
- Scientific and engineering timeframe not aligned with policy
- Pilot and demonstration projects provide critical insights
- Policy drivers are necessary to facilitate commercialization
- Regulatory, legal, and social factors require significant time investment

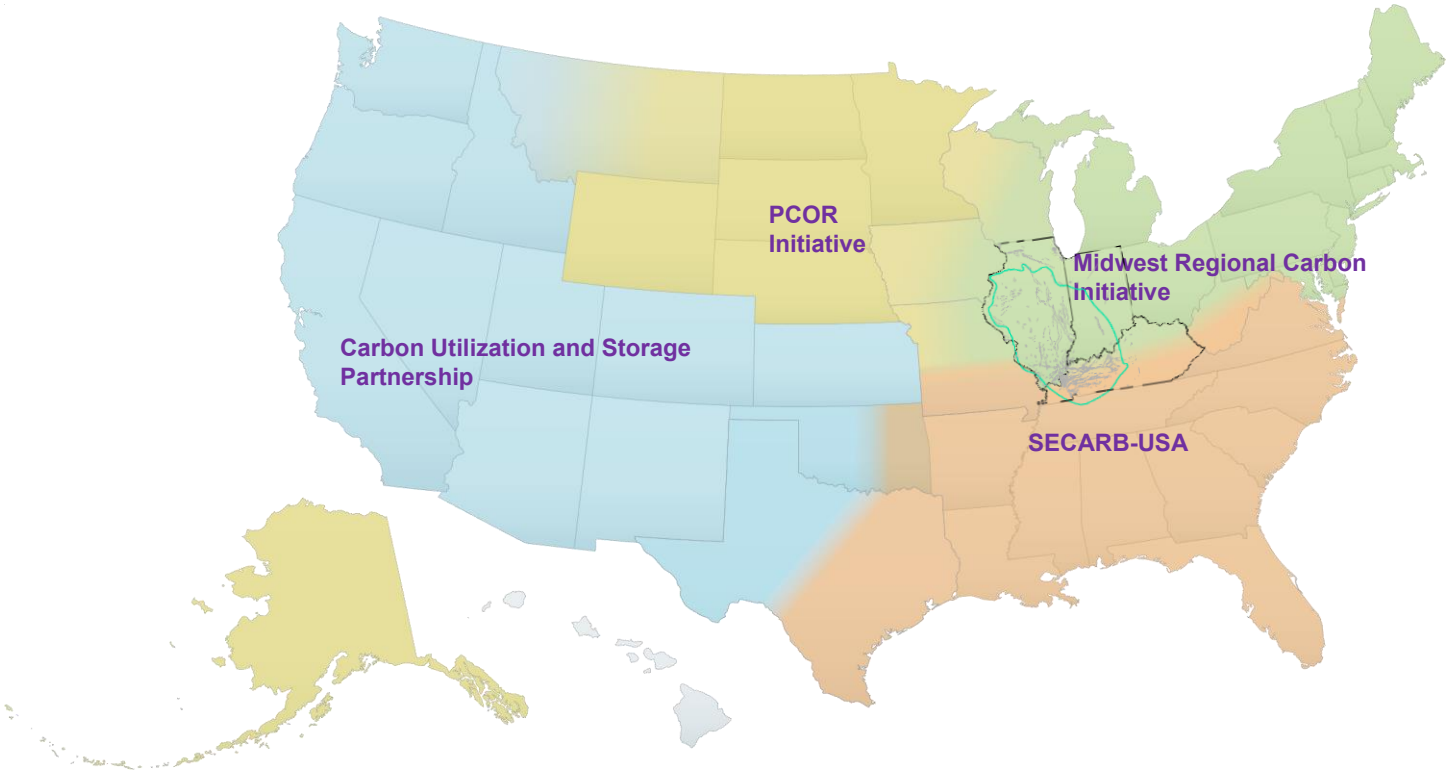


Preserving our Legacy:
Publications - American Geosciences Institute Portal
Data sets- EDX and CO2Data Share Network

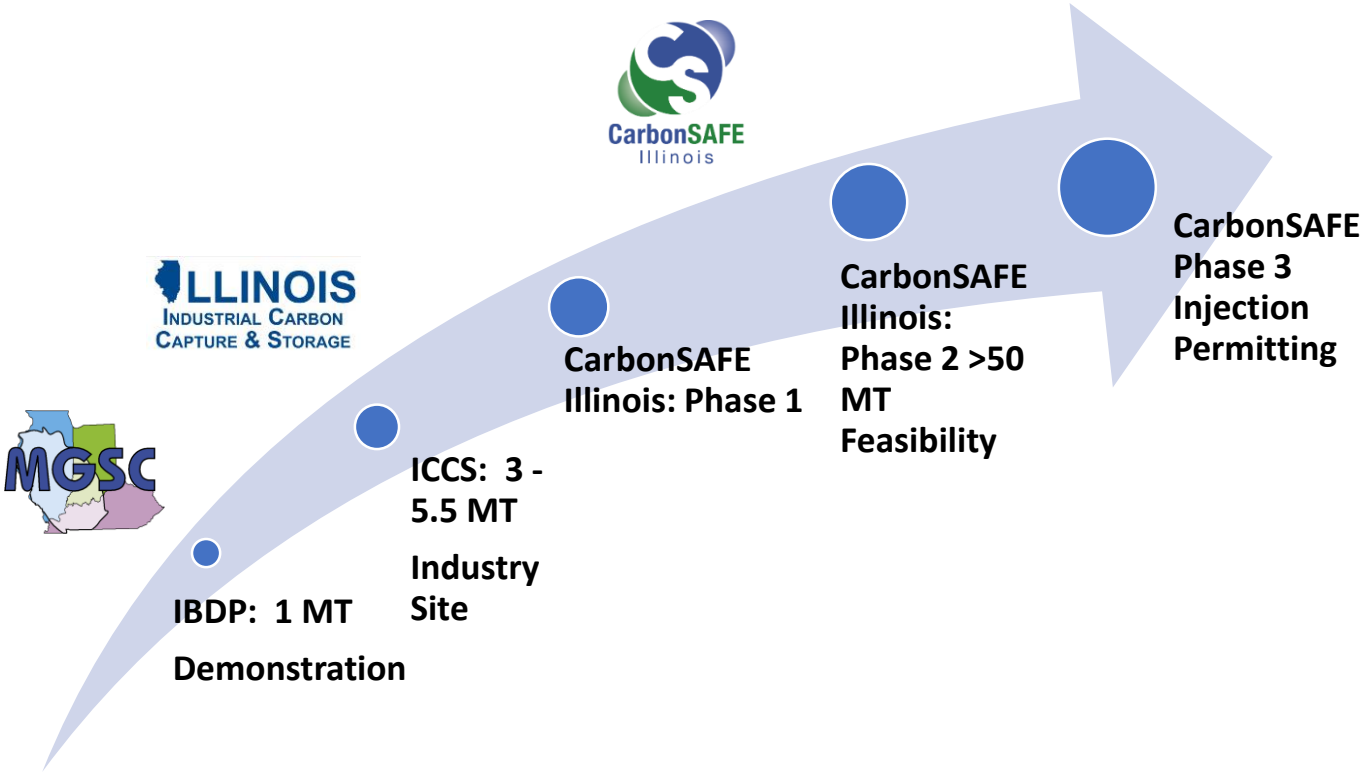
Decommissioning

- Smooth handoff to ADM and MVA group
- Groundwater research wells
- Equipment and site clean-up
- Data
- Websites
- Property transfer

Regional Initiatives to Accelerate CCUS



Leveraging CCS Experience in the Illinois Basin



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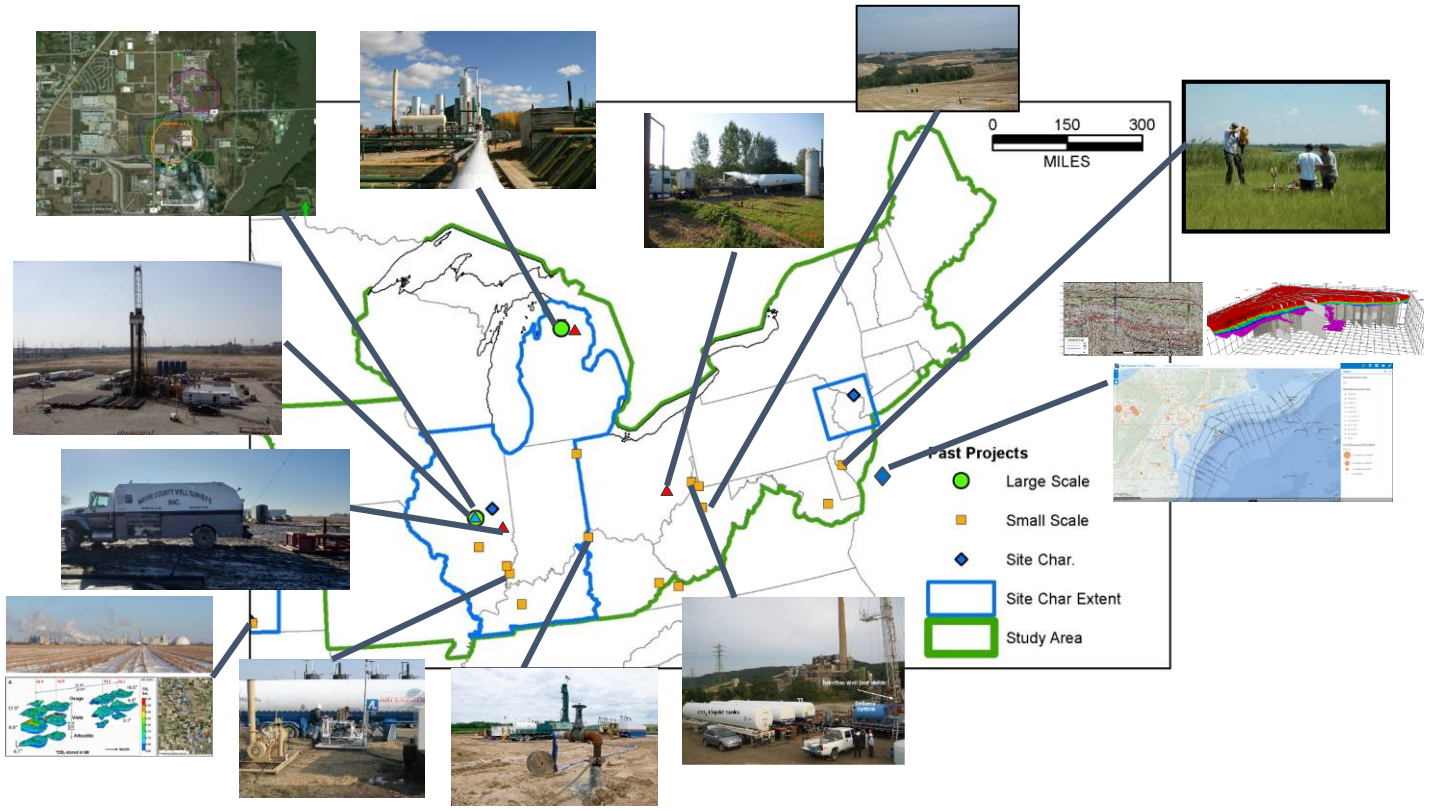
Expanding Scope and Scale

- Multiple pilot and full-scale projects conducted in the region provide a solid foundation for moving forward



Advancing technology: Deepening Understanding through Experience

Depth: Additional Sites for Characterization

Assurance: Flexible and Adaptive Monitoring Programs

Infrastructure: Integrating Multiple Projects

Systemic Connections for Technical, Regulatory, Social, and Legal

Changing the Conversation – But How?

- Concentrate effort on engagement and new conversations
- Working outside our box
- Embracing paradox and complexity
- Challenging our preconceptions and assumptions
- Get messy
- Build new dialog with shared language
- Work on sense-making in new reality
- Recognizing the world has changed and so have we

Because energy is so available and reliable *"it has become figuratively invisible, laying the groundwork for a public that believes they no longer require it."* Tisha Schuller, Adamantine Energy

Thank you for 17 years of Research, Partnership, Collaboration, and Contribution.

We would not be here without your support.

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- The MGSC is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky

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