Midwest Geological Sequestration Consortium

News from the Illinois Basin – Decatur Project

Sallie E. Greenberg, Ph.D.
Energy Research & Development
University of Illinois – Illinois State Geological Survey

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Acknowledgements

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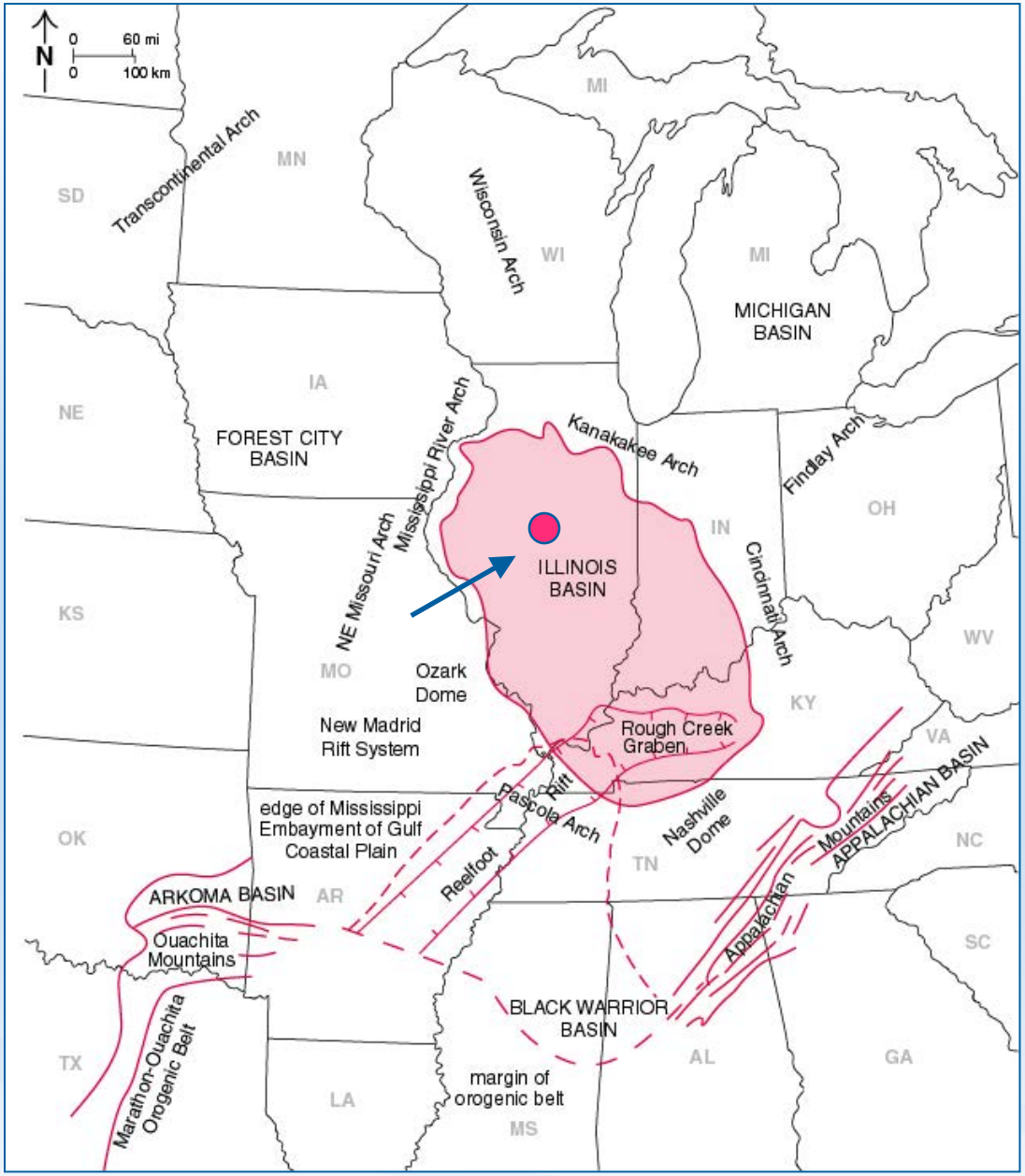
- The Midwest Geological Sequestration Consortium (MGSC) is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky.

- Landmark Graphics software via their University Donation Program and cost share plus Petrel software via Schlumberger Carbon Services.

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 ~2,100 m to test geological carbon sequestration in a saline reservoir at a site in Decatur, IL

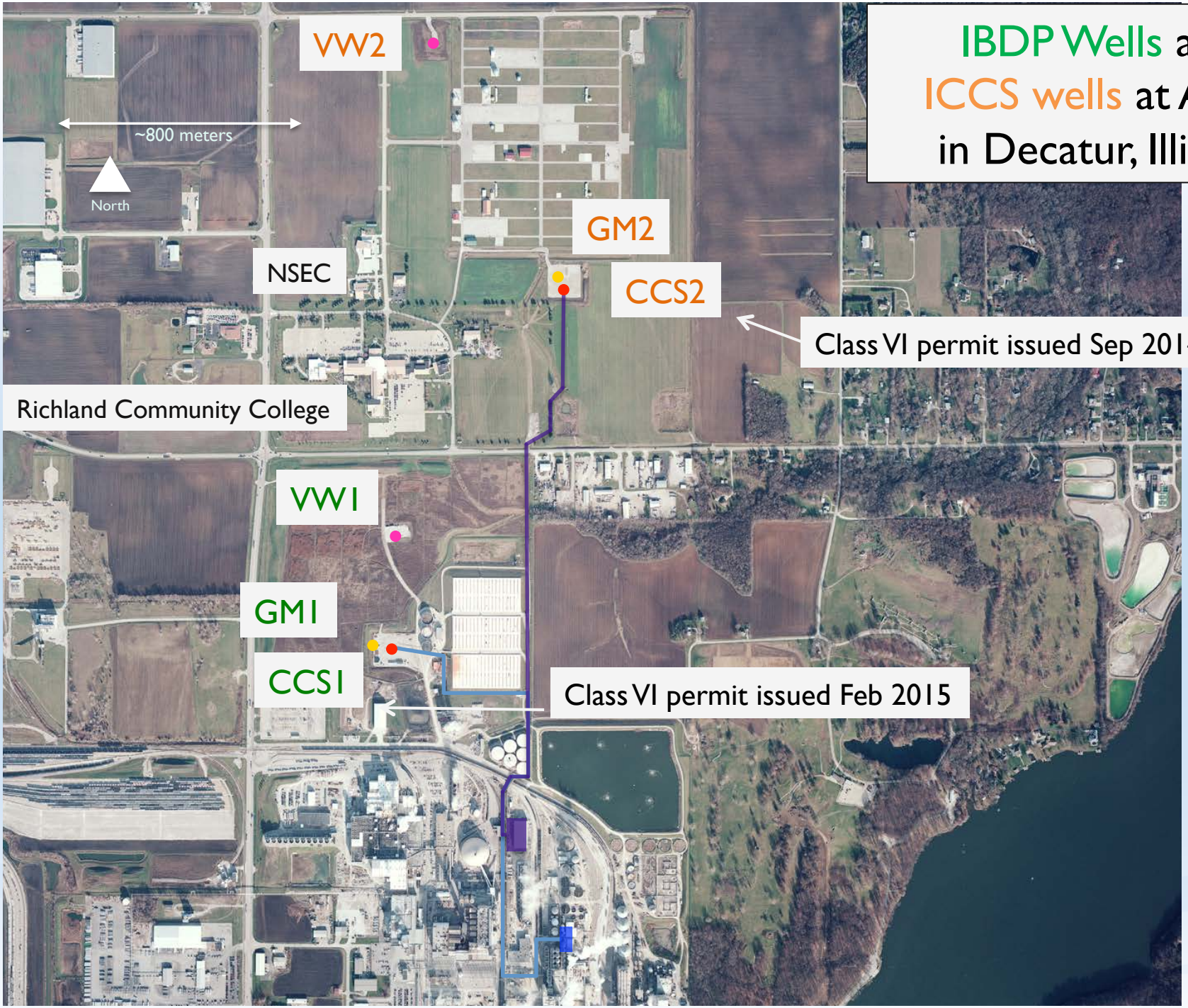
- Prove injectivity and capacity
- Demonstrate security of injection zone
- Contribution to best practices

Operational Injection: 17 November 2011

- IBDP is the first 1 million tonne carbon capture and storage project from a biofuel facility in the US
- Injection completed November 2014
- Intensive post-injection monitoring under MGSC through 2017

Total Injection
(26 November 2014):
999, 215 tonnes

IBDP Wells and ICCS wells at ADM in Decatur, Illinois



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,
  - Permission to inject pending

Post-Injection Activities

- 3D Surface Seismic Survey – January 2015
- Post-injection VSP, permit interim period – January 2015
  - Working to improve comparisons between repeat VSPs
- Post-injection near surface monitoring
  - Moving from injection monitoring to reduced program
- Recompletion of VW1 deep monitoring well
- Knowledge and data sharing best practices
  - Publications
  - National and international research collaborations
  - Collective and teaching data sets
  - Workshops

IBDP Risk Assessment and Project Uncertainties

Communication Plan & Implement

Communication and Crisis Management

2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

2008 Pre-Injection

- Identify FEP's and Scenarios
- Geologic Uncertainty
- Operational Uncertainty
- Regulatory Uncertainty
- Social Uncertainty

2013 Update

- New/Update FEP's and Scenarios
- Risk Treatments
- Regulatory Uncertainty
- Change in Scope
- Long-term Funding
- Knowledge Sharing
- Complacency Potential
- Institutional Memory Loss

2016 Post-Injection Updates

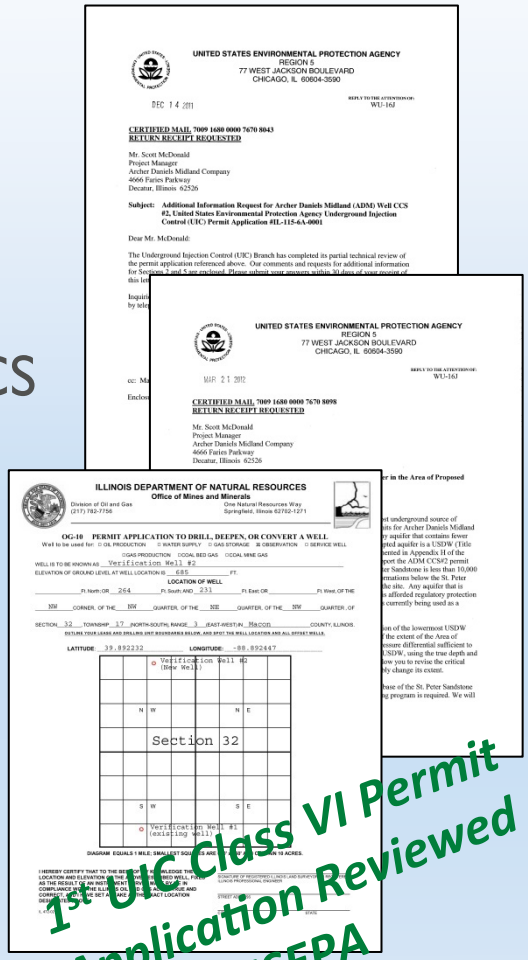
- New/Update Risks
- Risk Treatments
- Annual Review

- Government changes
- Well integrity
- Funding

Permitting of wells for two projects provides precedent for future projects

- 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: 6 Mar 2017 (EPA letter)
  - Appeal pending: Anticipated injection date ??



1st UIC Class VI Permit Application Reviewed by the USEPA

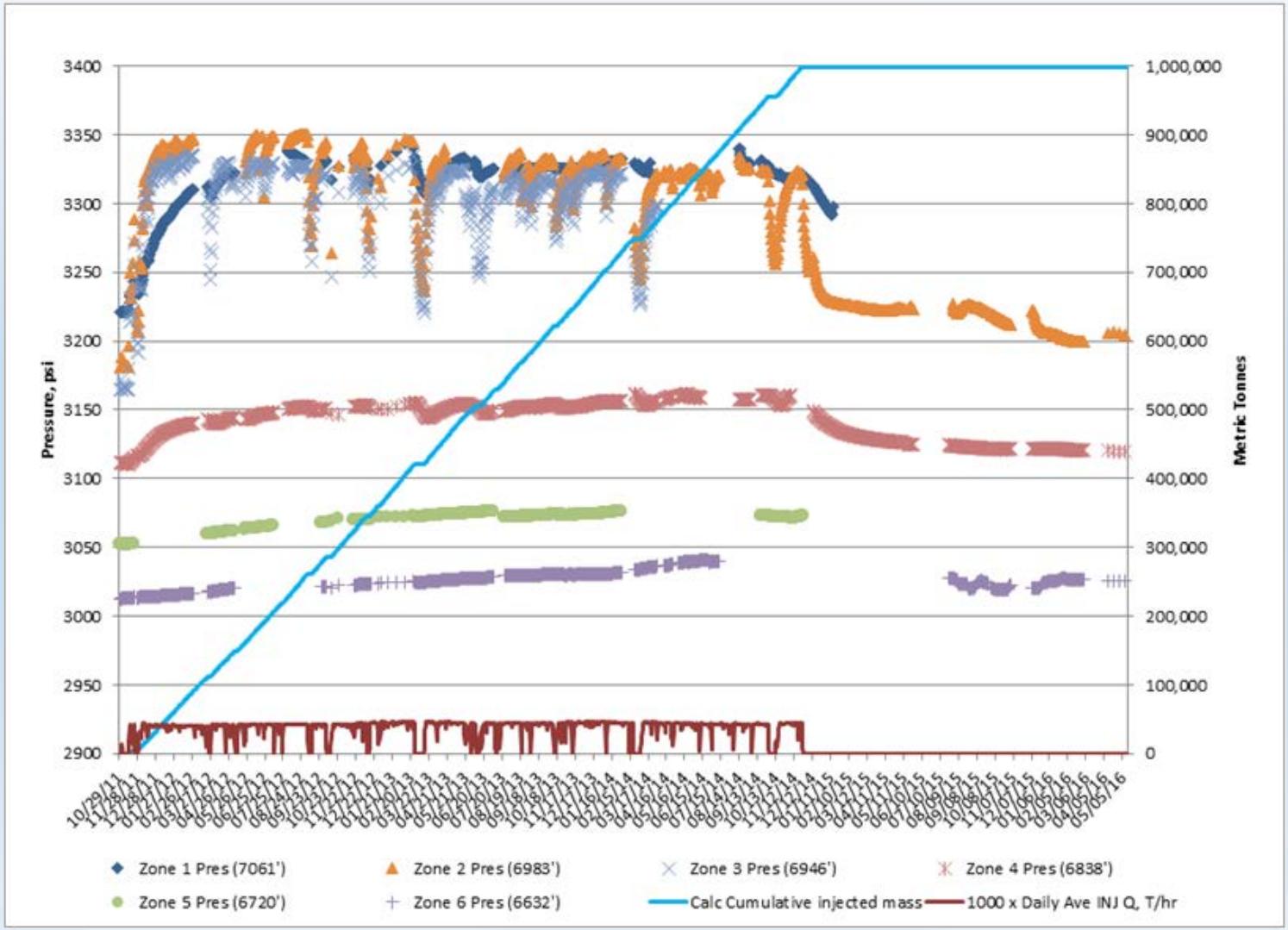
IBDP Monitoring Activity Summary

	Monitoring Activity	Freq.	Pre-injection			Injection				Post-Injection					
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Surface	Aerial imagery	SA		x	x	x	x	x	x	x	x	x	x	x	x
	Eddy covariance	C					x	x	x						
	Soil flux - network	W-Q		x	x	x	x	x	x	x					
	Soil flux - multiplexer	C			x	x	x	x	x	x					
	Tunable diode laser- single path	C					x	x							
	Tunable diode laser- multi path	C								x					
	InSAR	BW				x	x								
	Continuous GPS	C					x	x	x						
Near-Surface	Soil gas sampling	Q-A				x	x	x	x	x	x				
	Shallow groundwater sampling	M-Q-SA		x	x	x	x	x	x	x	x	x	x	x	x→
	Shallow electrical earth resistivity	A	x	x	x										
Subsurface	Pressure/temp. - VW1 and CCS1	C				x	x	x	x	x	x	x	x	x	x→
	Pulsed neutron (CCS1, VW1)	Q-A		x		x	x	x	x	x			x		x→
	Deep fluid sampling (VW1)	SA				x	x	x	x	x		x	x	x	
	Passive seismic monitoring (GM1)	C			x	x	x	x	x	x	x	x	x	x	x→
	Seismic/3D VSP imaging	SA-A			x	x	x	x	x	x					x→
	Mechanical integrity (CCS1, VW1)	A			x	x	x	x	x	x					x

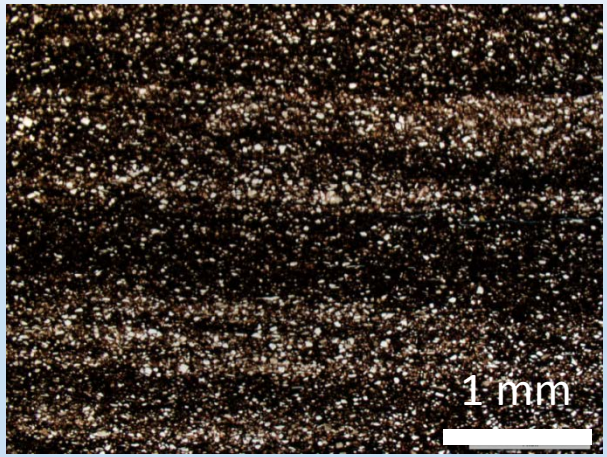
Red text = USEPA UIC Class VI required permit for an IBDP well (GM1, VW1, CCS1), x = planned, → = permit activity required beyond 2020;
Purple text = on-going MGSC, not permit required

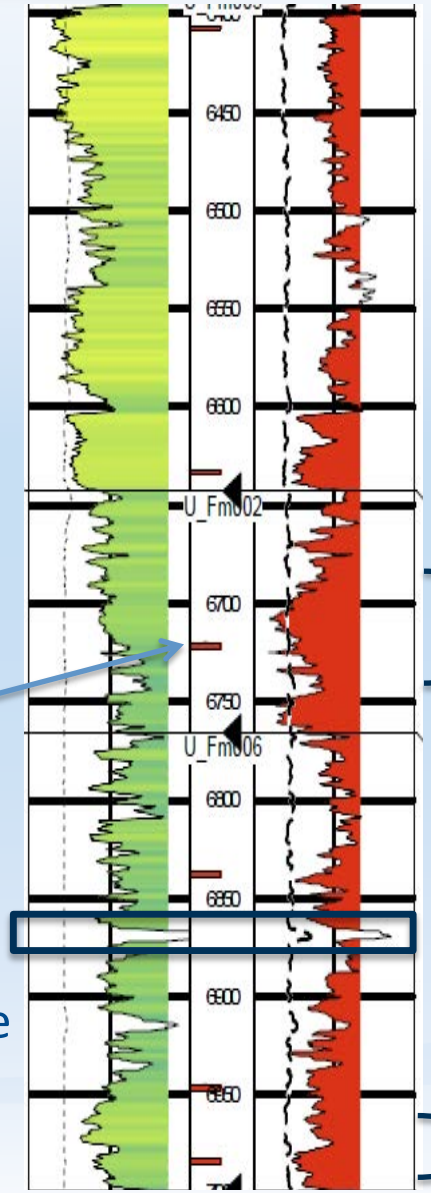
Abbreviations: C = Continuous, W = Weekly, BW = Biweekly, M = Monthly, Q = Quarterly, SA = Semi-Annually, A = Annually,

Pressure Response in VW1 Monitoring Well



Mudstone Baffle Between Injection Zones





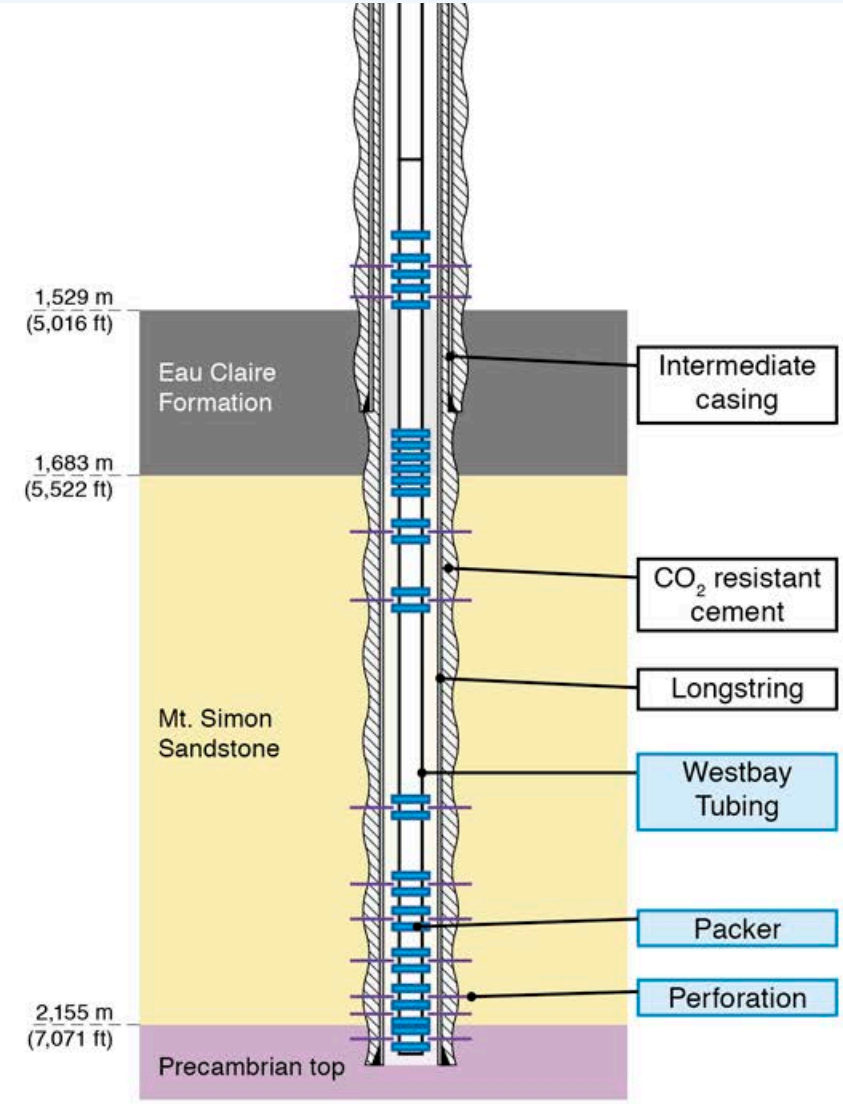
6,863-6,863.25

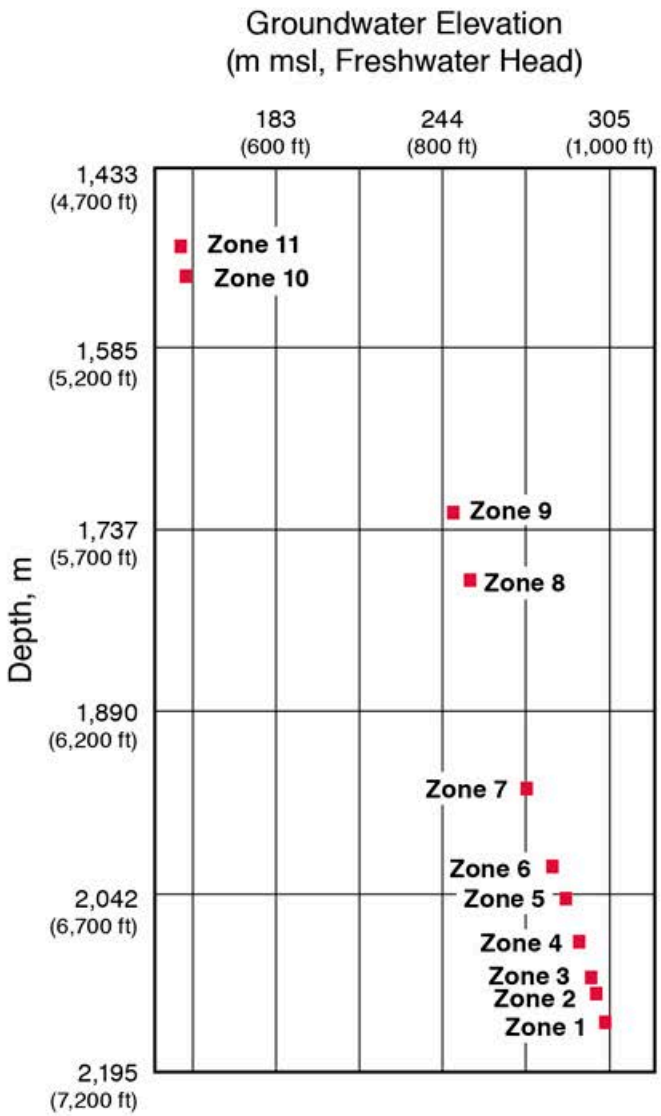
Porosity: 1.5%

K_v: <0.01 mD

K_h: 4.13 mD in siltstone laminae

Deep Monitoring Well - 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

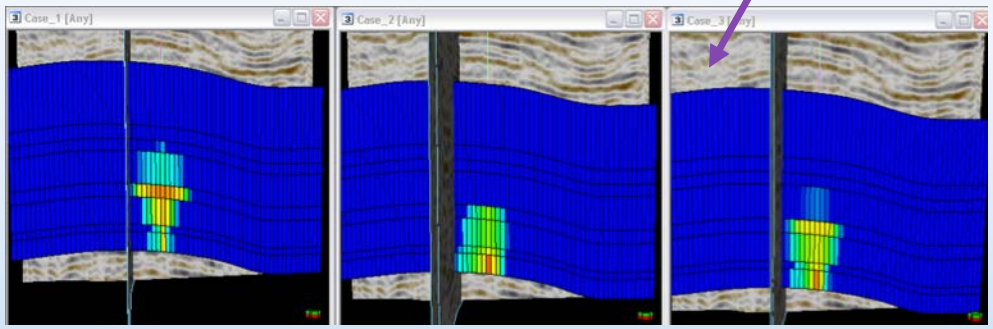
Two Fluid Sampling and Four Pressure Zones

Reservoir Model and Plume Forecasting

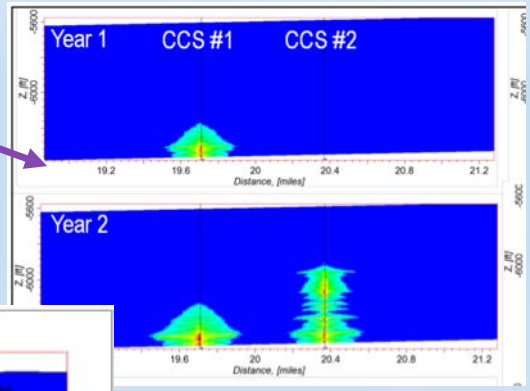
Six different model and plume forecast summaries conducted after major data sources collected and important project milestones

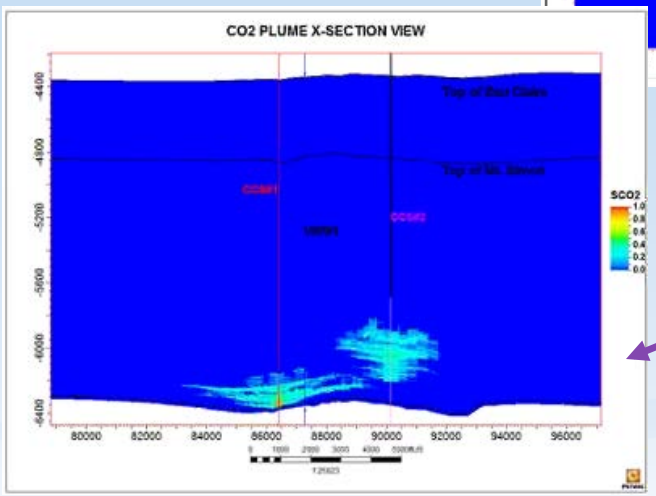
- Successive drilling and logging of new wells
- Core analysis and sampling data
- New seismic data acquisition
- Improvements in seismic processing
- EPA requests for plume forecasting updates

Pre-CCS1 Drill & Pre-injection



Post-CCS1 Drill & Pre-injection

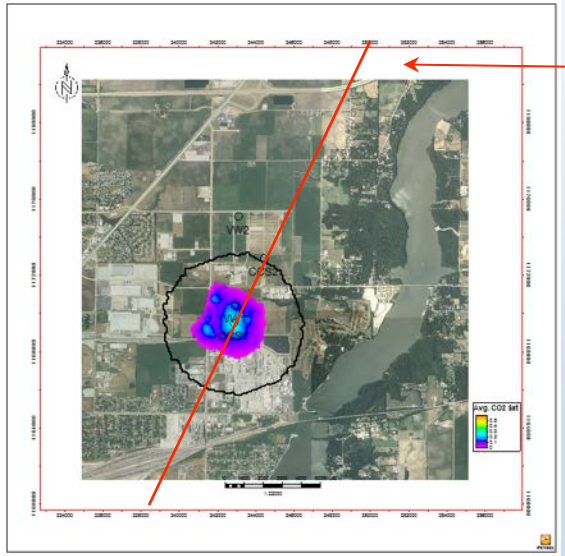




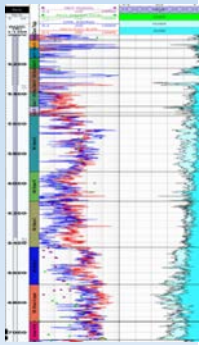
Post-CCS1 & VW1 Drill & Post-CCS1 injection

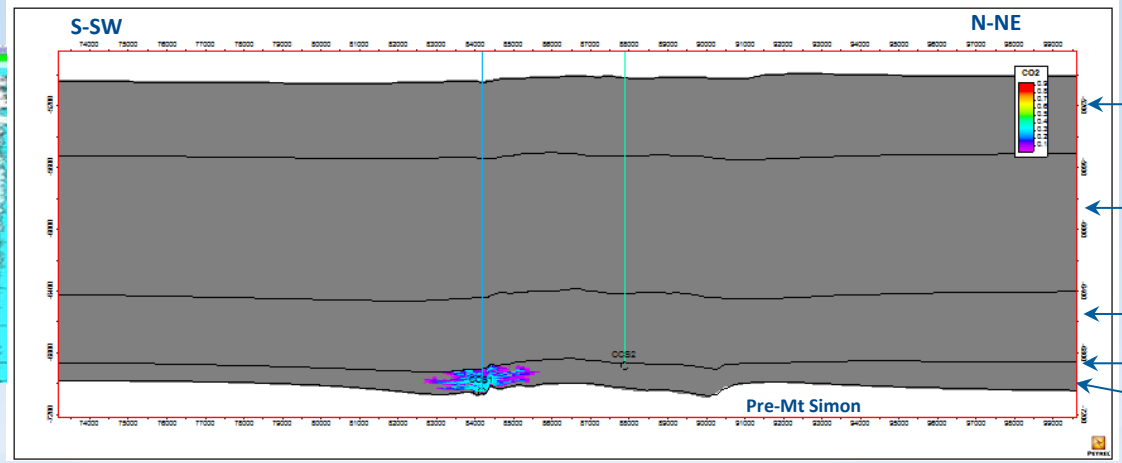
Extent of Plume & Saturation Cross Section
January 1, 2013 (year 1)

- Incremental update to previous version
- Created to update CCS2 Class VI plume forecasts
- Used final CCS2 perforation scheme
- Assumed CCS2 commence injection Jan 1 2015 at end of CCS1 injection)

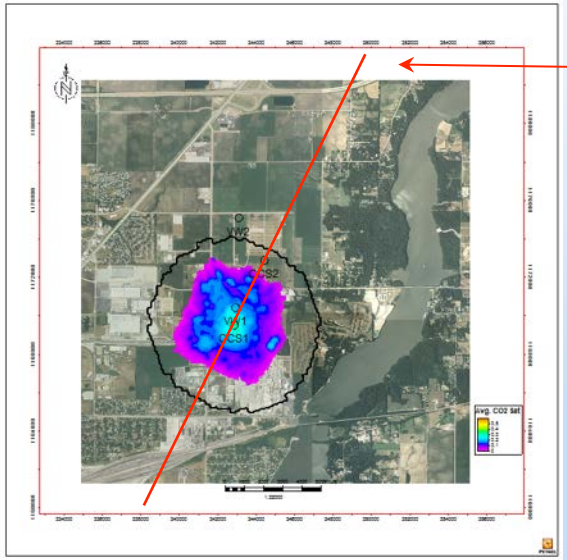


$DP_{if} \geq 86$ psi
$SCO_2 \geq 1.0\%$





Extent of Plume & Saturation Cross Section
January 1, 2015 (year 3, end of CCS1 injection)



— $DP_{if} \geq 86$ psi
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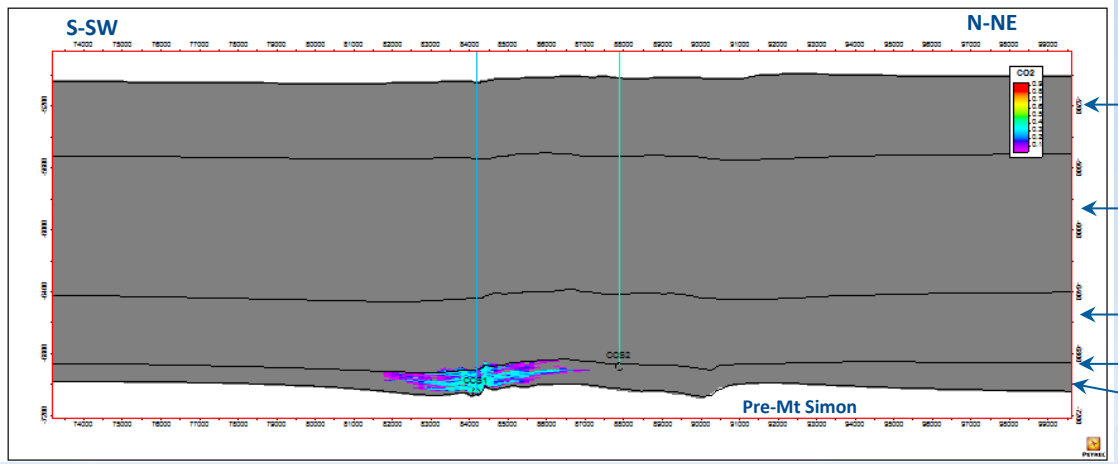
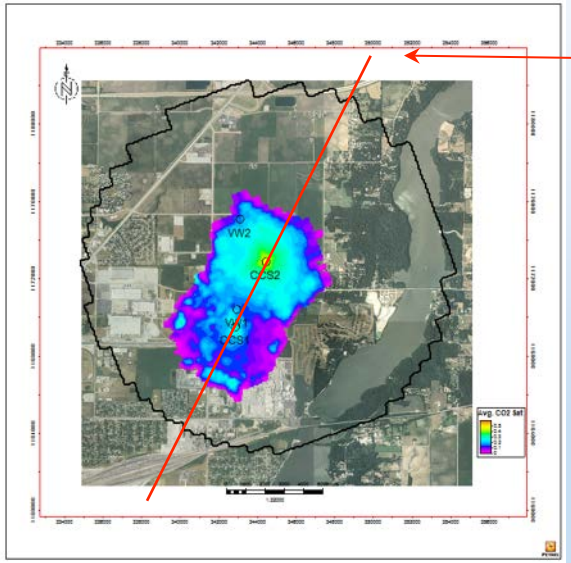
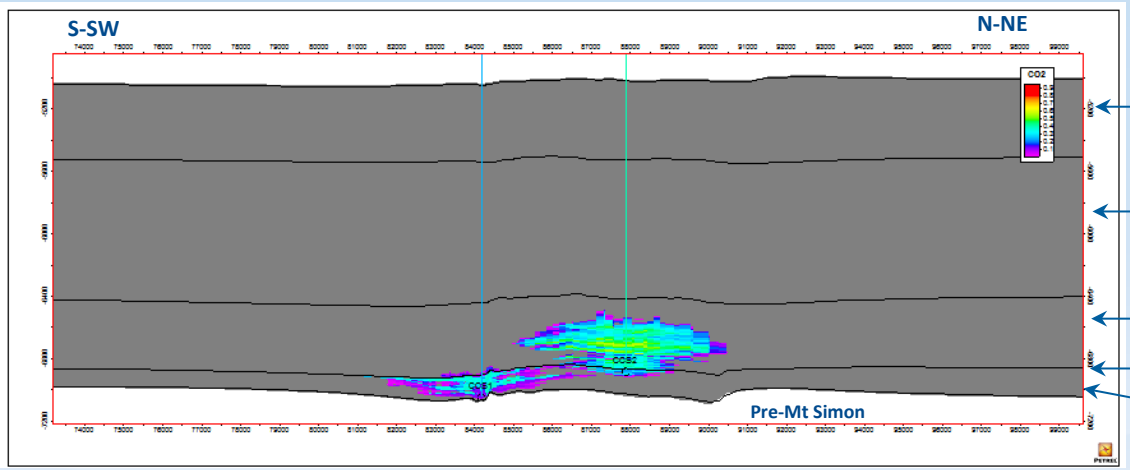


Extent of Plume & Saturation Cross Section
January 1, 2020 (year 8, end of CCS2 injection)



Cross Section Orientation

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



Eau Claire

Mt Simon C, D, E

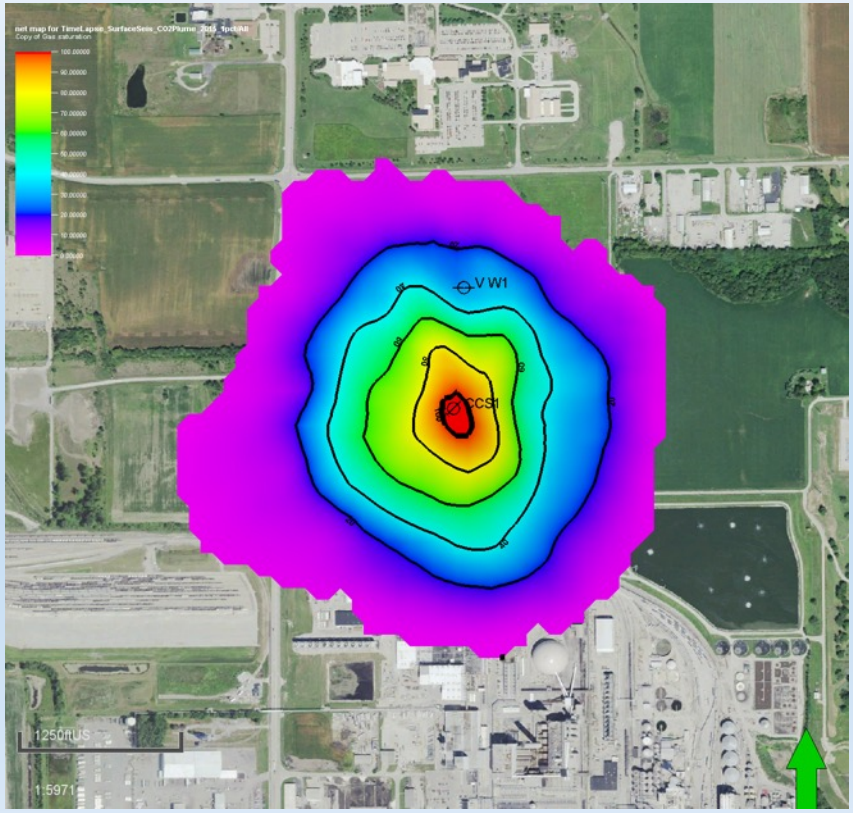
Mt Simon A, B

Mudstone

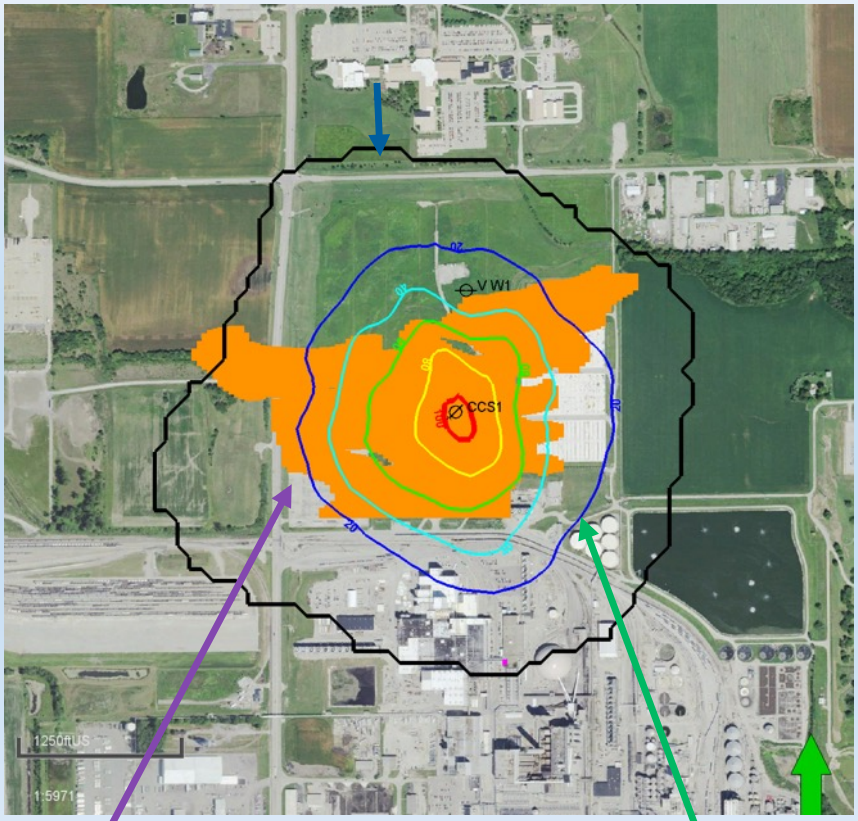
Lower Mt Simon A

Co-visualization of reservoir simulation results with time-lapse seismic attributes informs estimates of the seismic detection limit.

Simulated Net CO2 Saturation (integrated S_g x thickness)



Outline of plume as defined by 1 % CO2 saturation cut-off

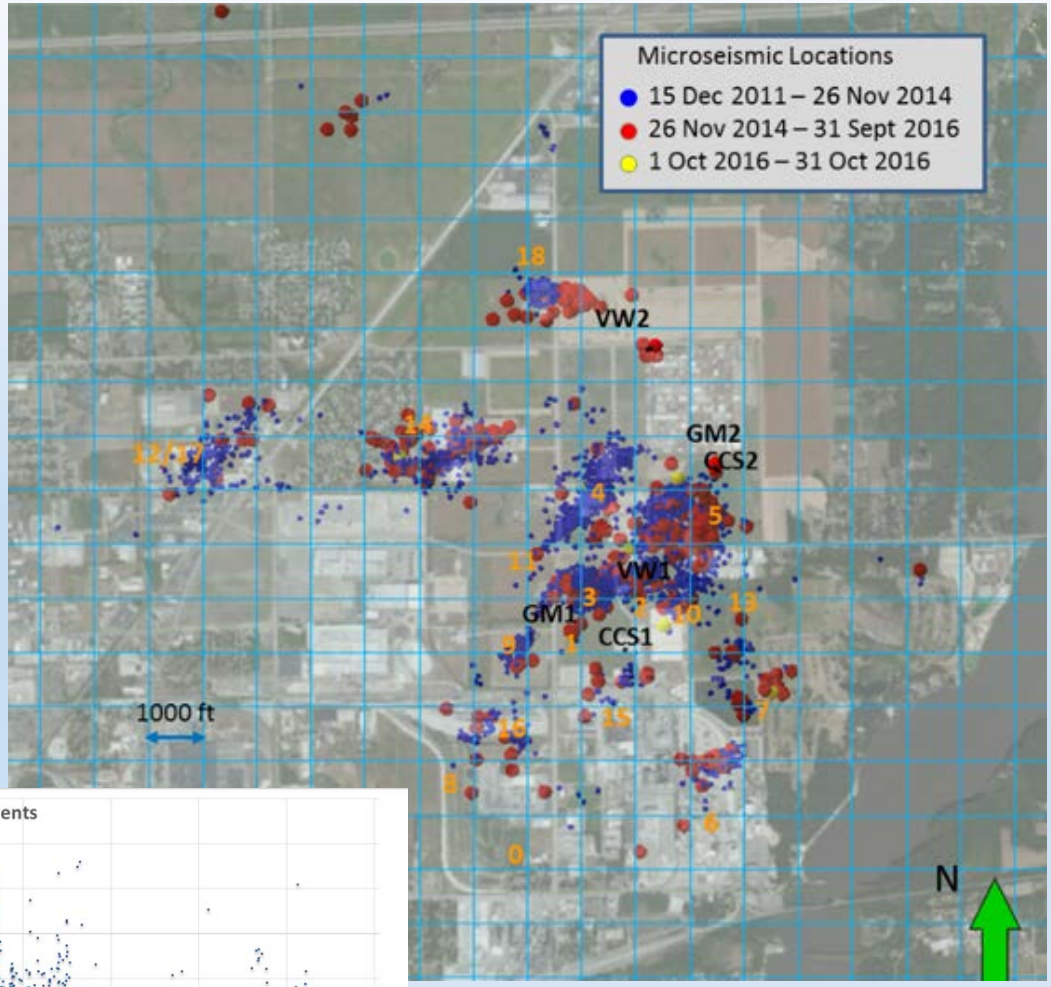


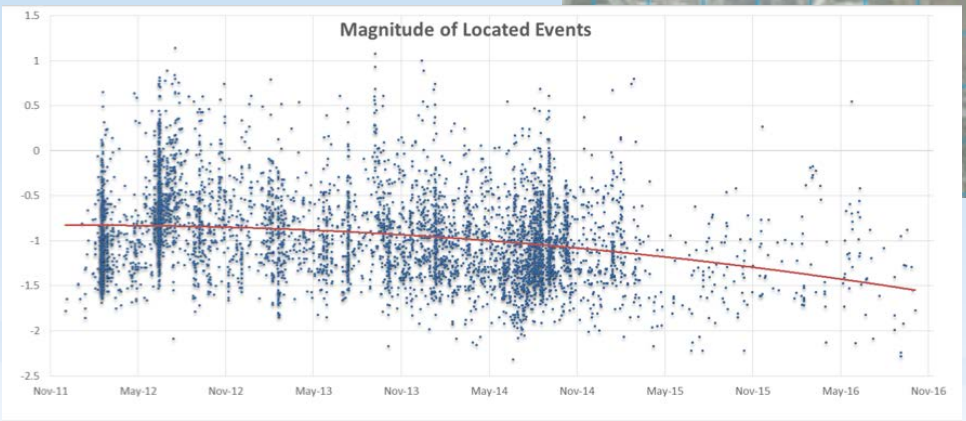
Measured 3D time-lapse displacement geobody.

Simulated Net CO2 Saturation (integrated S_g x thickness) contours.

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





By the numbers:

A million tonnes stored and…

More than **5,100 meters** of wells have been drilled

More than **245 meters** 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

More than **100 people at least 10 organizations** have worked together to make this project a success

XSEDE is an NSF-sponsored supercomputer network

Lessons Learned from IBDP

- Advanced technology deployment has associated risk.
- Technology choices can significantly impact long-term project operations
- Dependent upon best technology has to offer at the time
- Successful projects require significant resources to accomplish objectives
- Degree of risk can vary depending on nature of project (research, industrial, commercial)
- Monitoring programs should undergo periodic project-wide reviews
- Knowledge of reservoir characteristics evolves with additional data and site specific experience
- Modeling workflows should account for rapid iteration with systematic improvement
- Baseline activities need to be monitored prior to injection, during injection, and post-injection to fully understand reservoir response and residual stress
- Community engagement requires dedicated personnel, continual monitoring, and significant time to build trust and provide information

Conclusions

- 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

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NETL

VW1 Pulsed Neutron Logging

RST Monitoring Mar 2011 and Nov 2015

- CO_2 arrival before Mar 2012
- CO_2 saturation increasing though Nov 2015
- CO_2 above the "LPS" is uncertain