



**2014 SECARB Stakeholders Meeting**  
*March 4 & 5, 2014*  
*Atlanta, GA*

**Bruce Brown**

Infrastructure and Regional Partnership  
Coordinator  
March 4, 2014

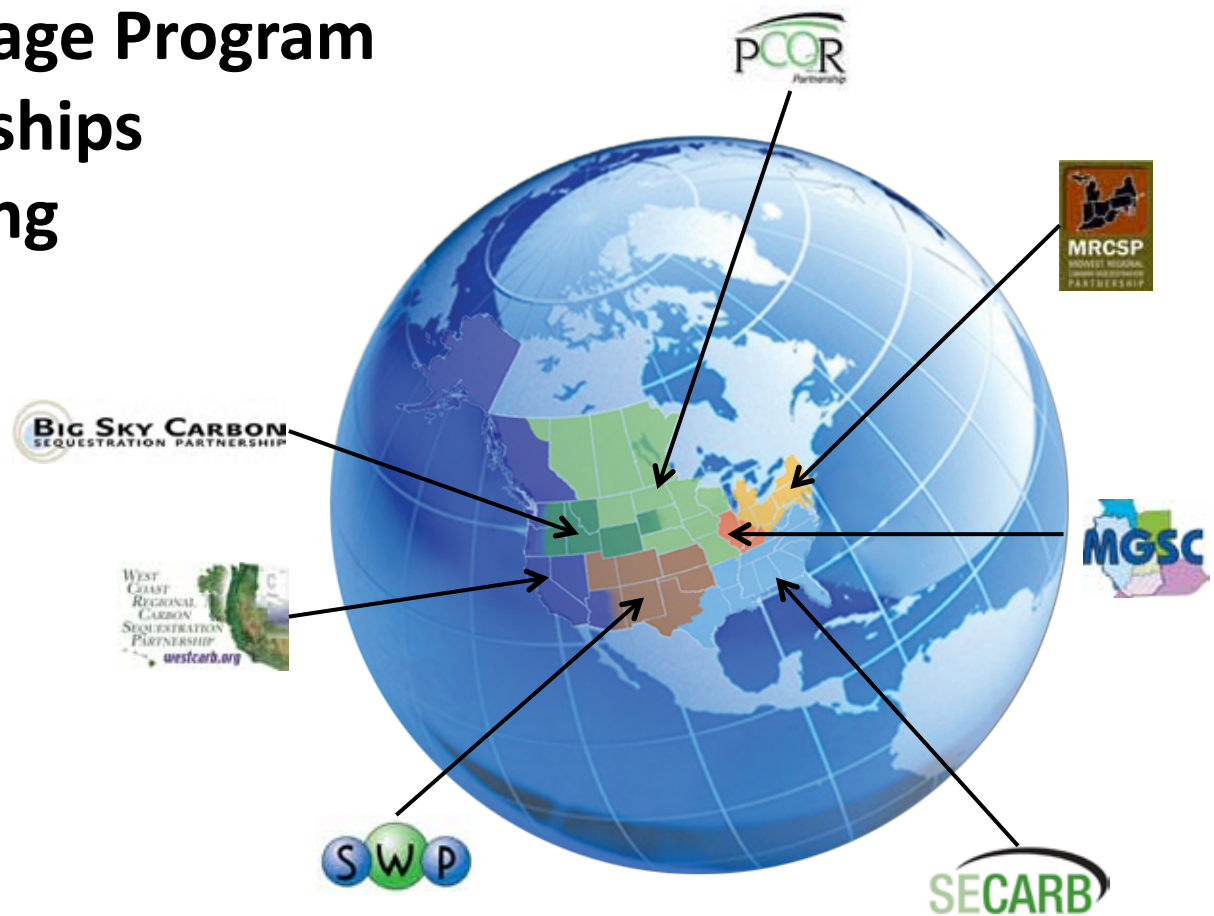
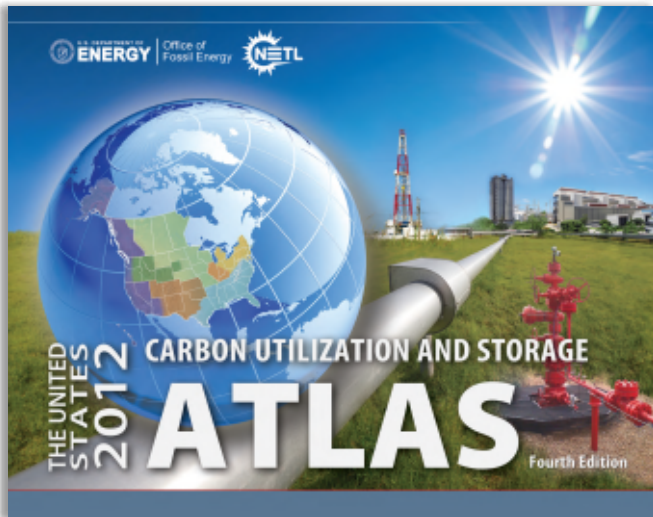


U.S. DEPARTMENT OF  
**ENERGY**

National Energy  
Technology Laboratory

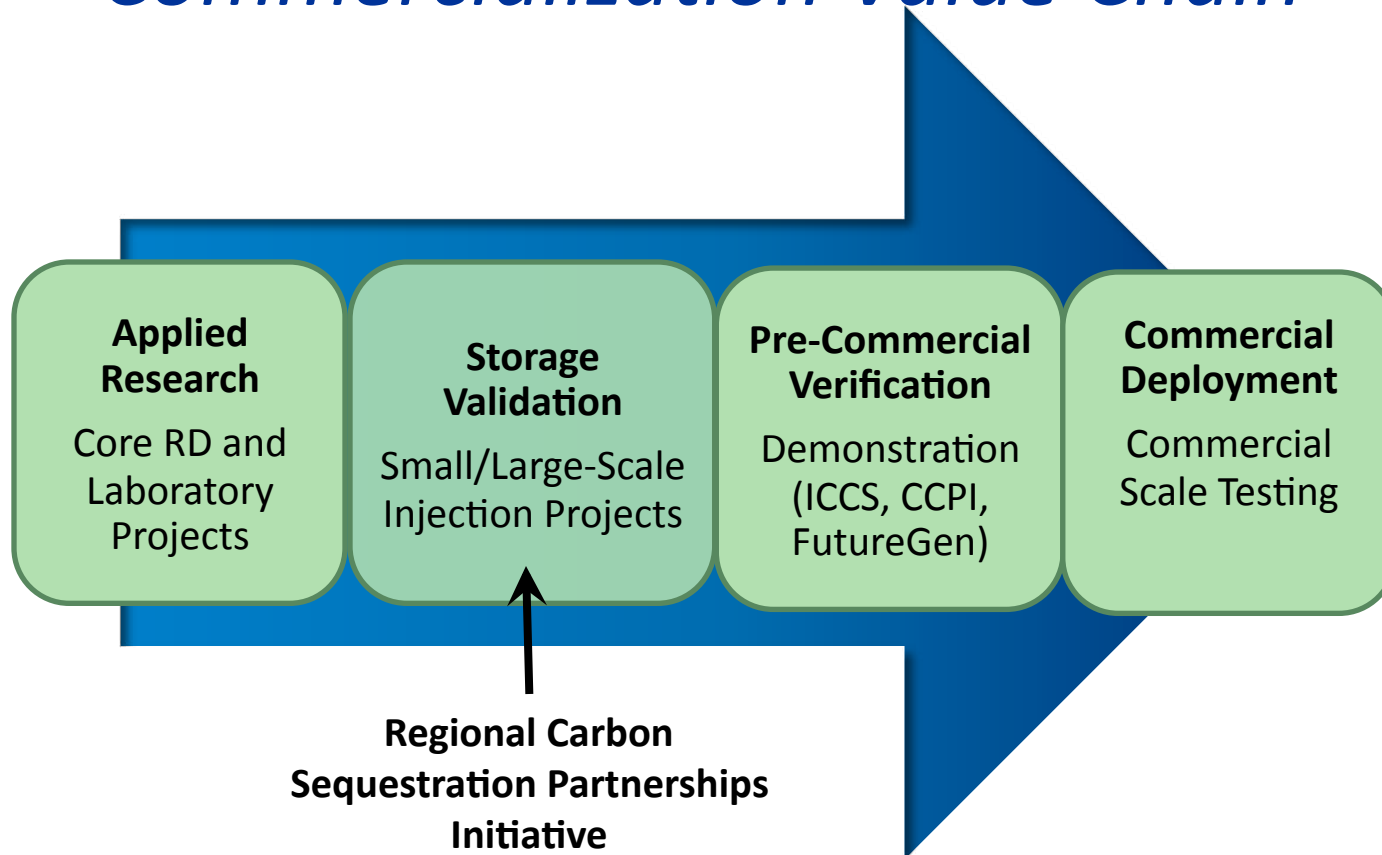
# Overview

- DOE Carbon Storage Program
- Regional Partnerships
- Knowledge sharing



# Geologic Storage

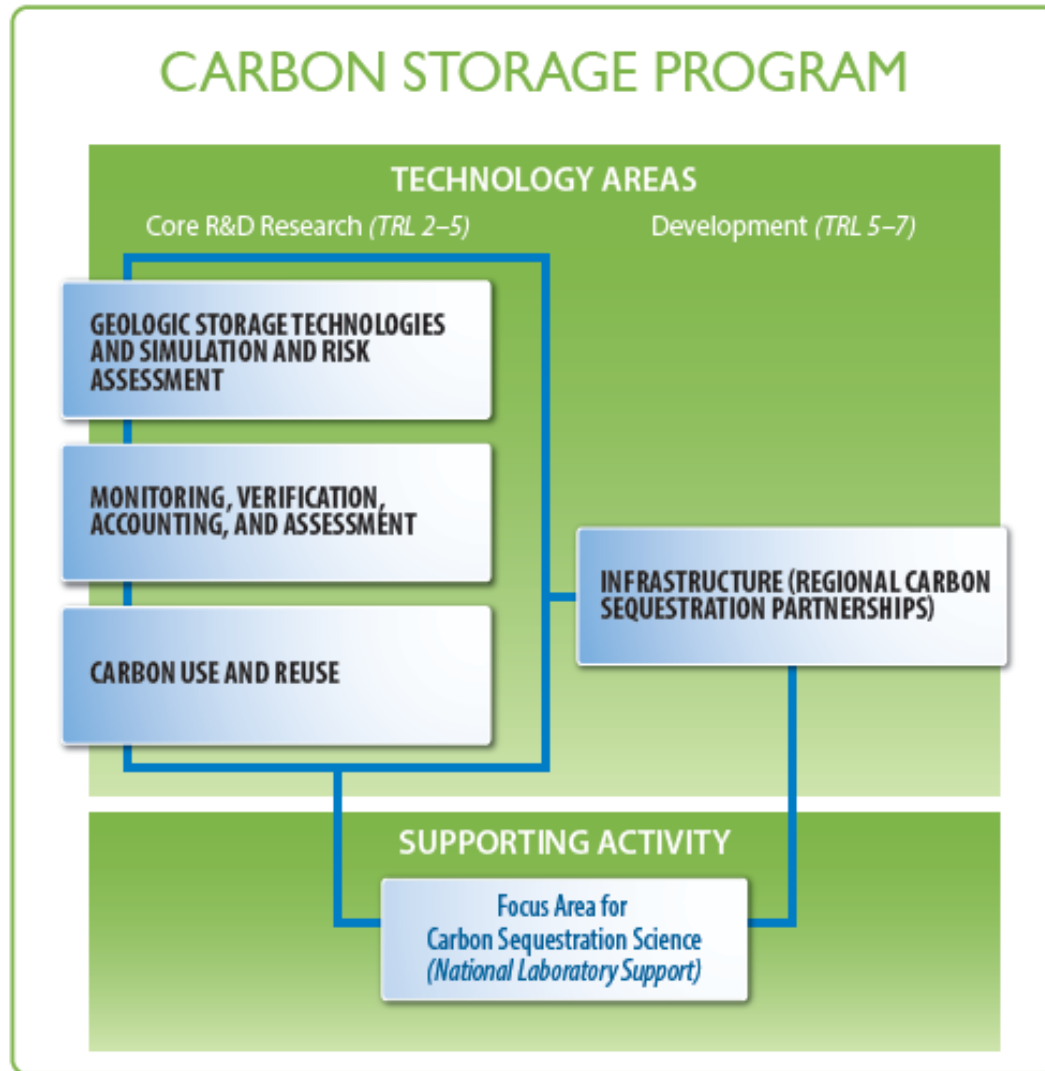
## *Commercialization Value Chain*



*Advancing CCS through an Integrated Value Chain from Research to Commercial Deployment*

# Carbon Storage Program

## *Technology Areas*



### Program Goals

- Ensure 99% Storage Permanence
- Improve Storage Efficiency
- Estimate Capacity +/- 30%
- Best Practices Manuals

### Benefits

- Mitigate GHG Emissions
- Credits for CO<sub>2</sub> Storage
- Increased Oil/NG Recovery
- Reduce Capital and O&M Costs
- Reduce Environmental Footprint

# Carbon Storage Program Budget

## *FY12 through FY14*

Carbon Storage Program Budget (Dollars in Thousands)	FY2012 Current	FY2013 Current	FY2014 Omnibus
Storage Infrastructure/Regional Carbon Sequestration Partnerships	83,190	76,961	72,000
Geological Storage Technologies & Simulation and Risk Assessment	14,978	14,254	16,300
Monitoring, Verification, Accounting and Assessment	6,738	6,412	10,000
Carbon Use and Reuse	778	740	800
Focus Area for Carbon Sequestration Science	9,726	9,256	9,800
<b>Total</b>	<b>115,410</b>	<b>107,624</b>	<b>108,900</b>
Program Target: Since 2009, millions of cumulative metric tons of CO <sub>2</sub> injected	3.0	4.0	5.0

### FY2014 budget supports:

- Development and validation of technologies, infrastructure, and human capital through Storage Infrastructure/RCSPs.
- Continue support of Core R&D activities, such as Geologic Storage and MVA.
- Carbon use and reuse technology development.

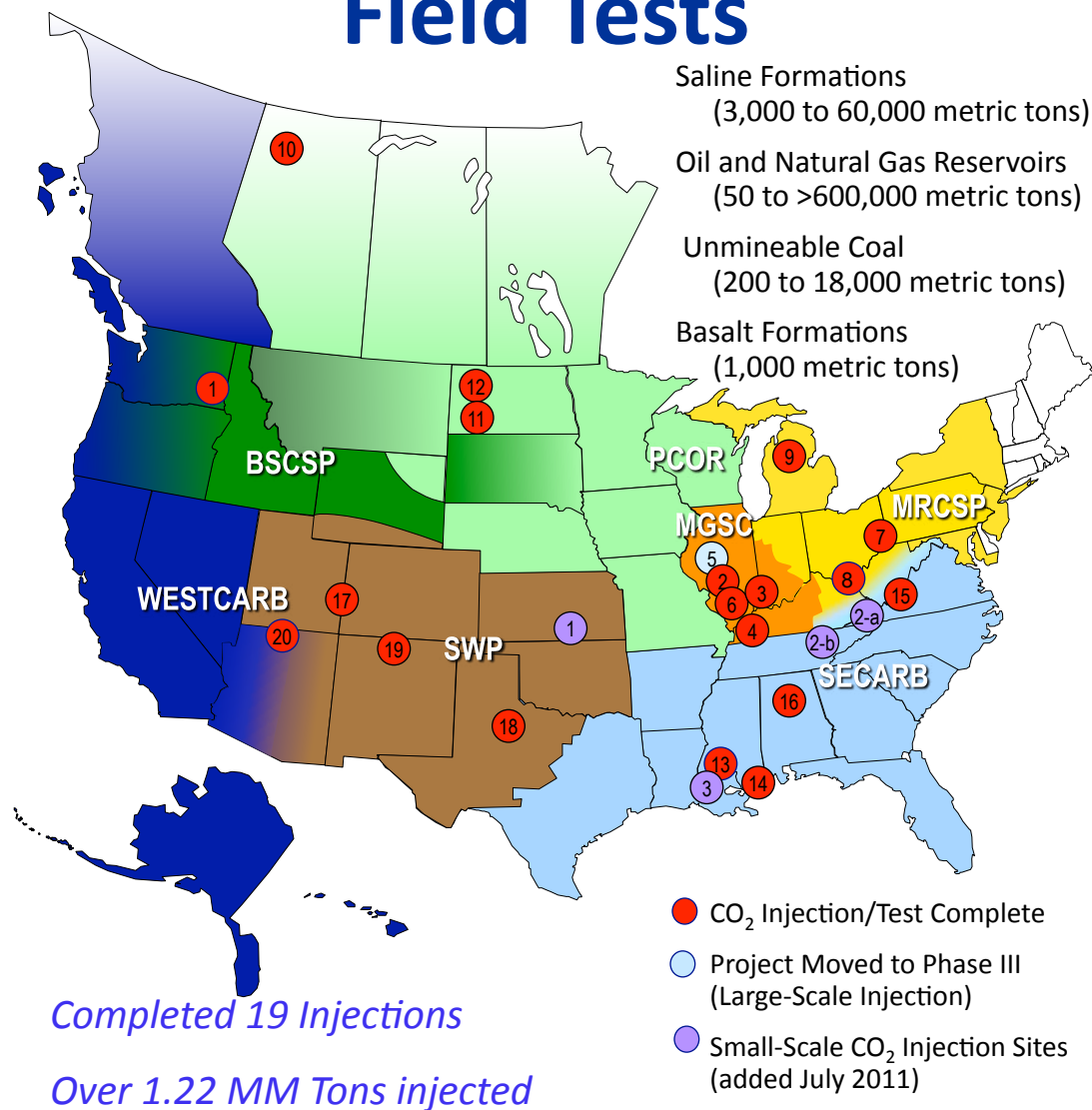
# Regional Carbon Sequestration Partnerships

## *DOE Field Activities in different reservoir classes*

Geologic Storage Formation Classification:		Deltaic	Shelf Clastic	Strandplain	Lacustrine	Eolian	Fluvial and Alluvial	Turbidite	Shelf Carbonate	Reef	Coal/ Shale	Basalt (large igneous provinces)
Reservoir Class												
Large-Scale Field Projects <sup>2</sup>	Saline				--		3		1	--		
	EOR			1	--		2 <sup>4</sup>			1		
Small-Scale Field Projects <sup>3</sup>	Saline	1	1	1					2			1
	EOR	2	2		--		1		3	2	7	
NOTES:												
(1) The number in the cell is the number of investigations by NETL per geologic storage formation classification.												
(2) Large-scale field projects: injection of more than 1,000,000 metric tons of CO <sub>2</sub> .												
(3) Small-scale field projects: injection of less than 500,000 metric tons of CO <sub>2</sub> for EOR and 100,000 metric tons for saline formations.												
Site characterization: characterize the subsurface at a location with the potential to inject at least 30,000,000 metric tons of CO <sub>2</sub> .												
(4) One large-scale project involves both EOR and saline storage												



# Small-Scale Geologic Field Tests

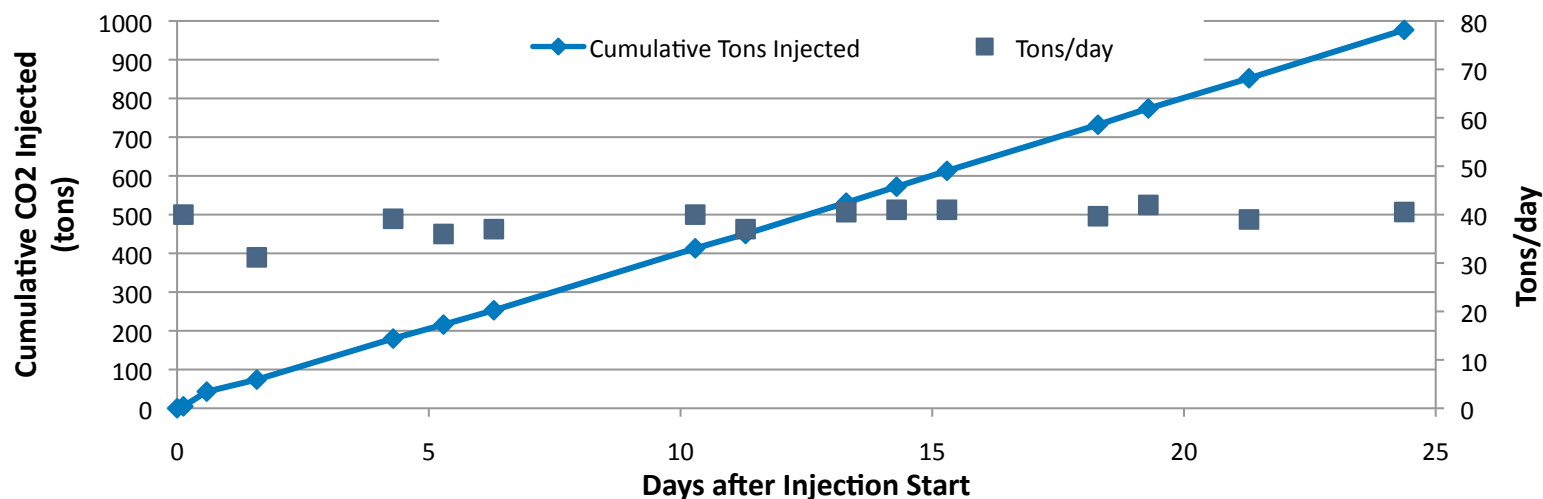


RCSP	Formation Type	Reservoir Class (Geologic Provenance)
<b>BIG SKY</b>	SALINE 1	Basalt (Columbia Basin)
<b>MGSC</b> Midwest Geological Sequestration Consortium	OIL-BEARING 2 3 4 SALINE 5 COAL SEAM 6	Deltaic, Shelf Clastic, Fluvial, Coal (Illinois Basin)
<b>MRCSP</b> Midwest Regional Carbon Sequestration Partnership	SALINE 7 8 9	Shelf Carbonate, Strandplain, Shelf Clastic (Cincinnati Arch, Michigan Basin, Appalachian Basin)
<b>PCOR</b> The Plains CO <sub>2</sub> Reduction Partnership	OIL-BEARING 10 11 COAL SEAM 12	Shelf Carbonate, Reef, Coal (Keg River, Duperow, Williston Basin)
<b>SECARB</b> Southeast Regional Carbon Sequestration Partnership	OIL-BEARING 13 SALINE 14 COAL SEAM 15 16	Fluvial, Deltaic, Coal (Gulf Coast, Mississippi Salt Basin, Central Appalachian, Black Warrior Basin)
<b>SWP</b> Southwest Regional Partnership on Carbon Sequestration	OIL-BEARING 17 18 COAL SEAM 19	Reef, Shelf Carbonate, Coal (Paradox Basin, Permian Basin, San Juan Basin)
<b>WESTCARB</b> West Coast Regional Carbon Sequestration Partnership	SALINE 20	Shelf Carbonate (Colorado Plateau)
Other Small Scale Injections	Formation Type	Reservoir Class
University of Kansas	OIL-BEARING & SALINE 1	Shelf Carbonate (Sedwick Basin)
Virginia Tech	COAL SEAM 2-a ORGANIC SHALE 2-b	Coal (Appalachian Basin)
Blackhorse Energy, LLC	OIL-BEARING 3	Shelf Clastic (Gulf Coast)

# Big Sky Carbon Sequestration Partnership

## *Phase II – Basalt Pilot Test*

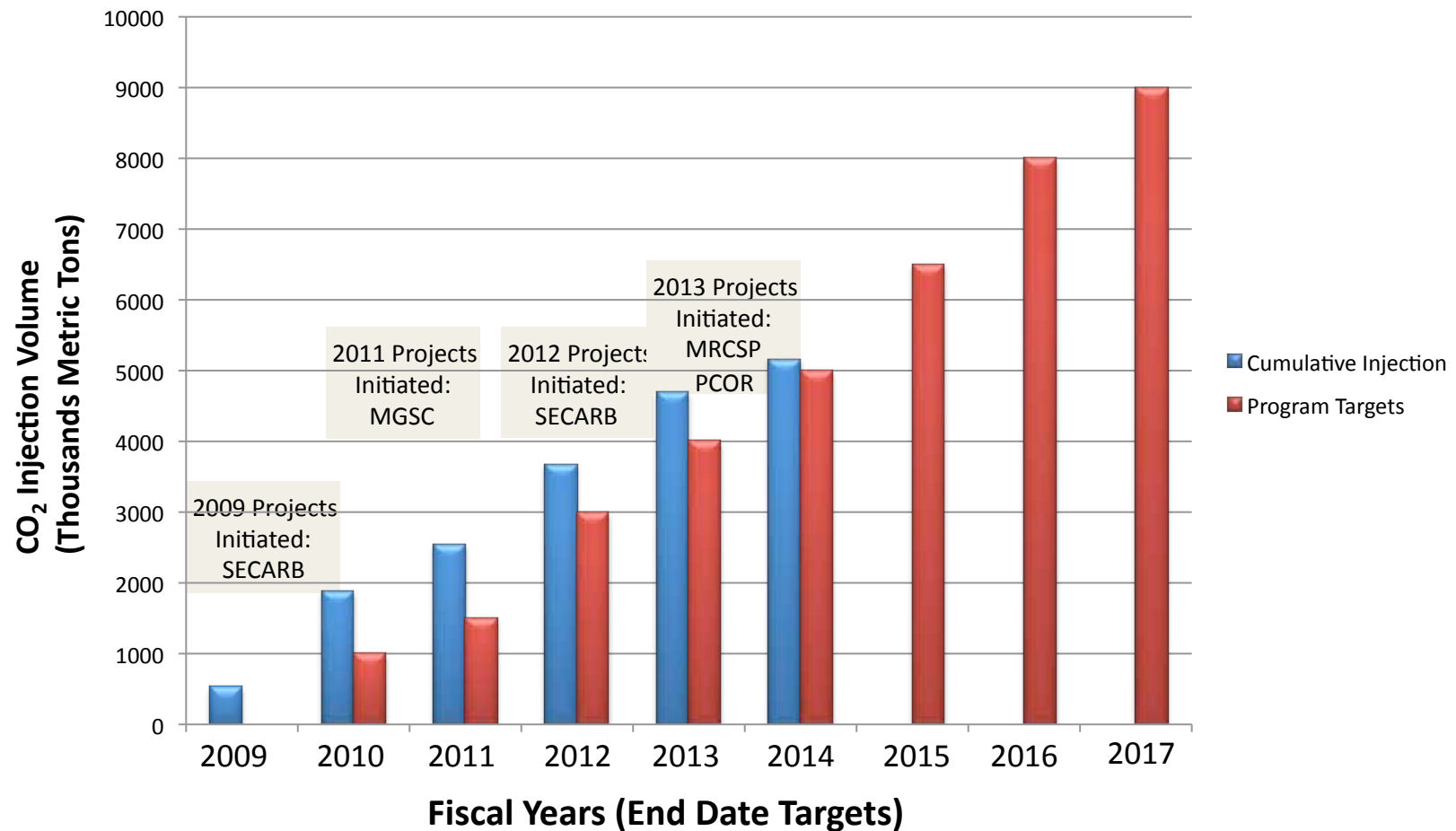
- Injection from July 17 to August 11, 2013
- Total mass injected: 977 Metric Tons
  - Intentional cutoff to avoid exceeding permit limit after final adjustments for Pressure and Temperature
- Average injection rate ~ 40 Tons/day
- Downhole pressure maintained within 400 psi above baseline
- No operational problems or unexpected events
- MVA activities will continue through September 2014





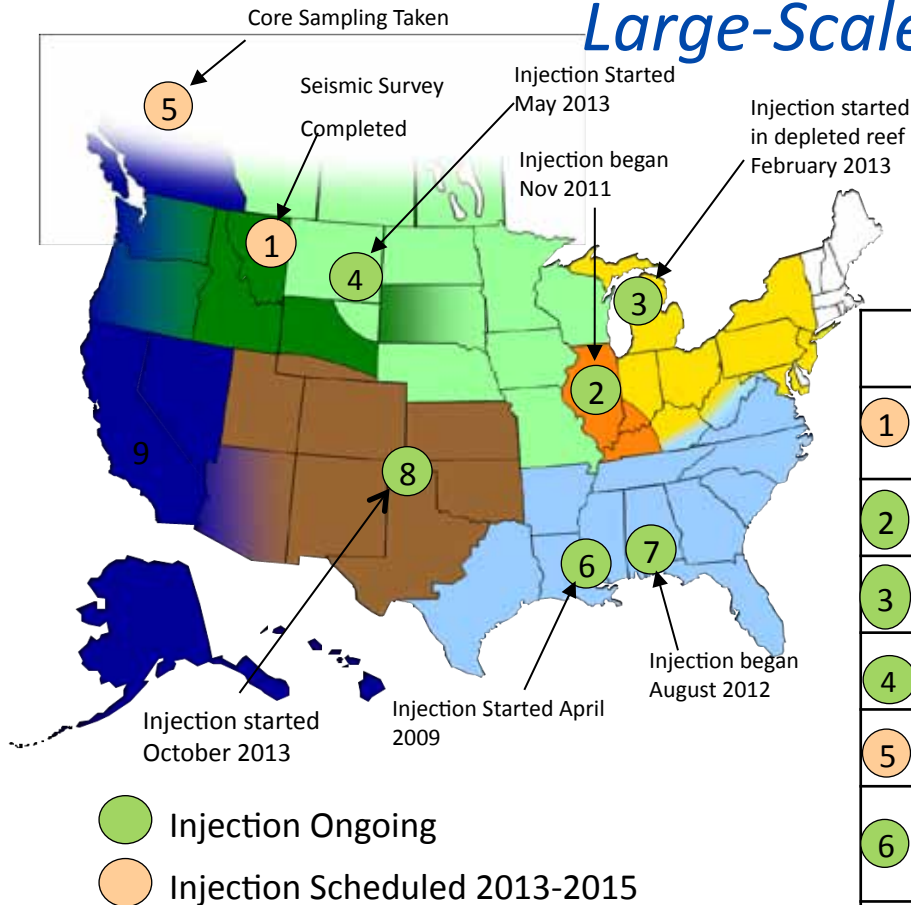
# RCSP Phase III: Development Phase

## *Programmatic Goals*



# RCSP Phase III: Development Phase

## Large-Scale Geologic Tests



Note: Some locations presented on map may differ from final injection location

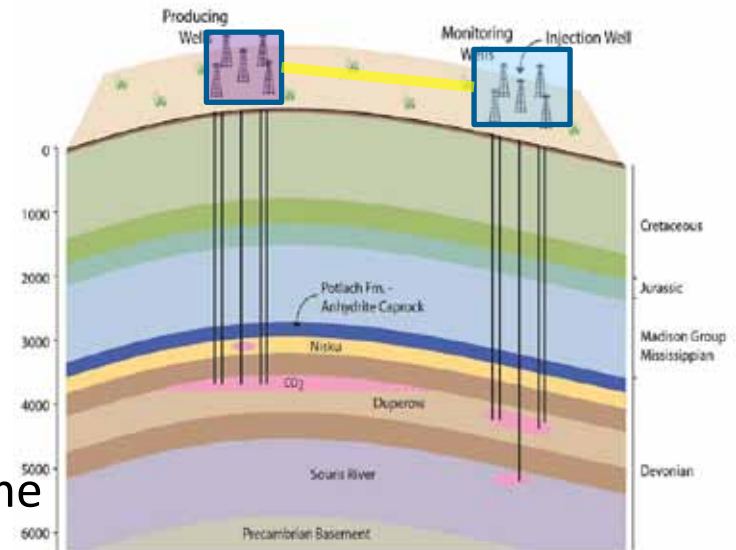
- ✓ Large-volume tests
- ✓ Four Partnerships currently injecting CO<sub>2</sub>
- ✓ Remaining injections scheduled 2013-2015

	Partnership	Field Project – Geologic Formation	Metric Tons Injected to Date
1	Big Sky	Kevin Dome- Duperow Formation	0
2	MGSC	Illinois Basin Decatur-Mt. Simon Sandstone	>745,000
3	MRCSP	Michigan Basin - Niagaran Reef	>185,000
4	PCOR	Bell Creek - Muddy Sandstone	>360,000
5		Fort Nelson - Sulfur Point Formation	0
6	SECARB	Early Test (Cranfield Field) - Tuscaloosa Formation	>3,900,000
7		Anthropogenic Test (Citronelle Field) – Paluxy Formation	>100,000
8	SWP	Farnsworth Unit - Morrow Formation	>37,000
	WESTCARB	Regional Characterization	

# Big Sky Carbon Sequestration Partnership

## *Phase III Kevin Dome Site Large-Scale Storage Project*

- **Target Formation:** Duperow Formation
- **Depositional Environment:** Shallow Shelf Carbonates (~4,000 feet)
- **Unique:** Saline storage demonstration with verification of storage capacity and injectivity in regionally significant dome
- **CO<sub>2</sub> Source:** Natural CO<sub>2</sub> at top of Kevin Dome
- **CO<sub>2</sub> Transportation:** 6 mile, 2-inch diameter pipeline
- **Status:**
  - Preparing permit applications
  - Conducting seismic surveys



# Midwest Geological Sequestration Consortium

## *Decatur Site Large-Scale Project*

- **Target Formation:** Mt. Simon Sandstone at ~7,000 ft depth
- **Depositional Environment:** Fluvial (braided stream with stream-margin aeolian and alluvial fans)
- **Unique:** Verifying storage capacity, injectivity and containment of the Mt. Simon Sandstone, a regional saline aquifer.
- **CO<sub>2</sub> Source:** Archer Daniels Midland Ethanol Plant
- **CO<sub>2</sub> Transportation:** ~ 1 mile pipeline
- **Status:** > 745,000 metric tons injected to date.

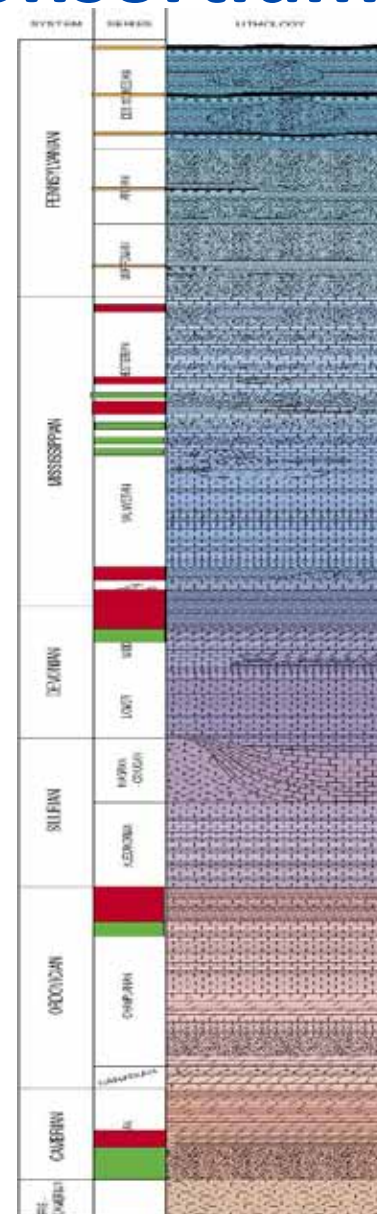


**New Albany Shale**

**Maquoketa Shale**

**St. Peter Sandstone**

**Eau Claire Shale – Primary Seal  
Mt. Simon Sandstone - Reservoir**

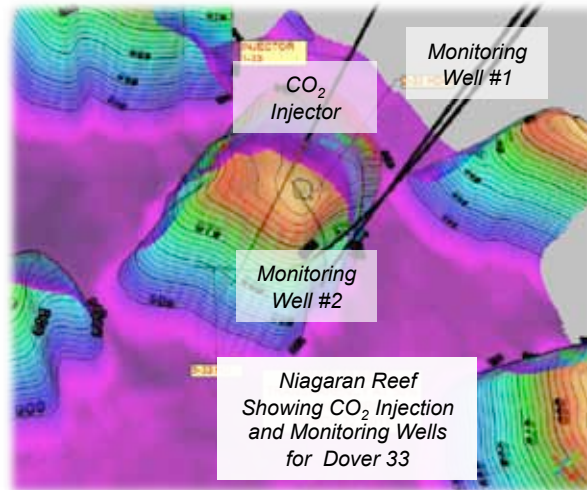
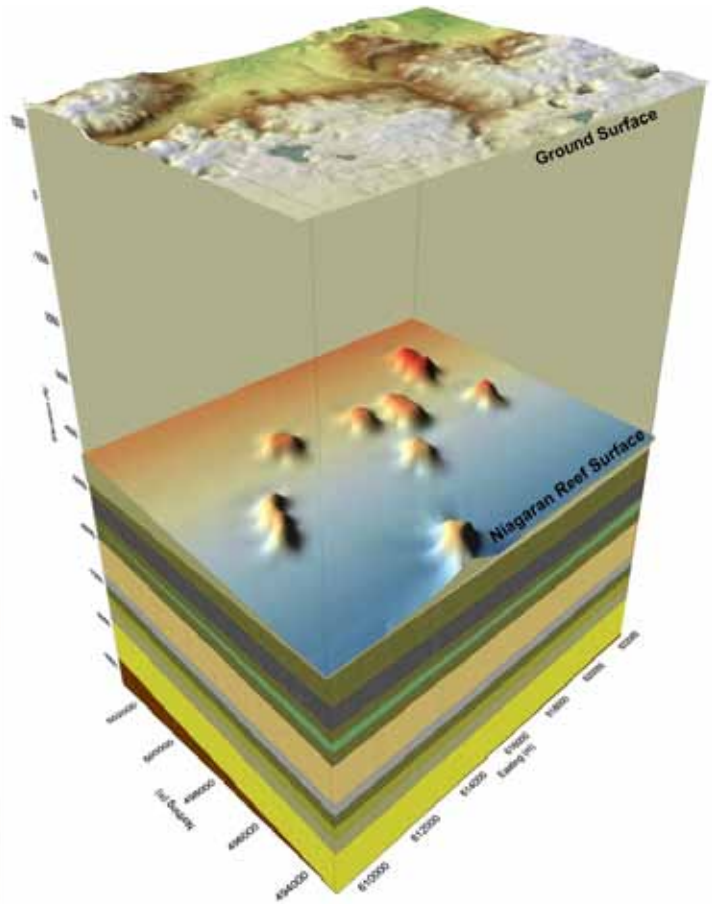




# Midwest Regional Carbon Sequestration Partnership

## Michigan Niagaran Reef Trend – Large Scale Injection Project

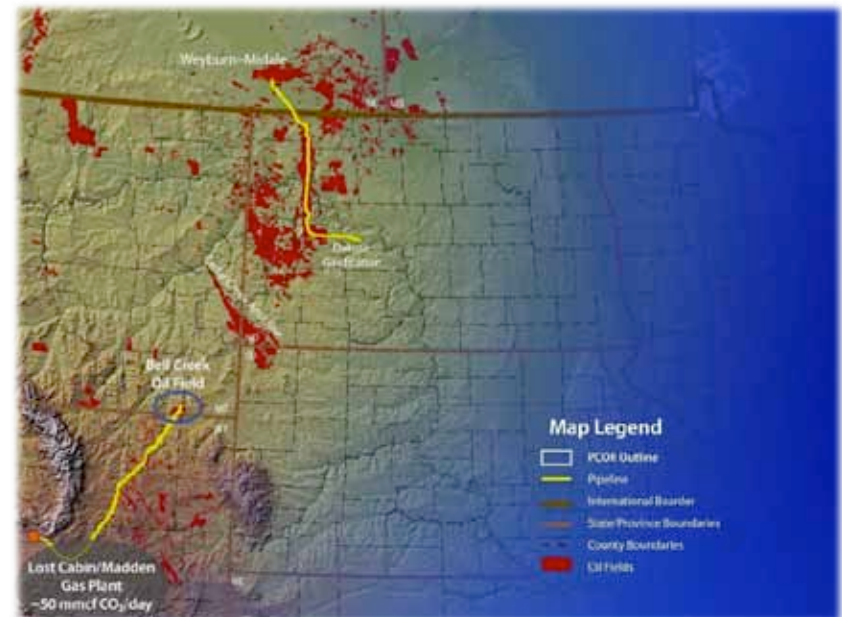
- **Target Formation:** Niagaran Reefs – Northern Michigan
- **Depositional Environment:**
  - Reef structures
  - Pinnacle Reef development followed by subaerial exposure which enhanced porosity and permeability
- **Unique:** Closely-spaced, highly compartmentalized, oil and gas fields
- **CO<sub>2</sub> Source:** Core Energy's Antrim Shale gas processing plant
- **CO<sub>2</sub> Transportation:** 15 mile pipeline
- **Status:** >185,000 metric tons to date



# Plains CO<sub>2</sub> Reduction Partnership

## *Bell Creek Site Large-Scale Project*

- **Target Formation:** Colorado Group/Muddy Sandstone Formation
- **Depositional Environment:** Strandplain (barrier bar) and fluvial deltaic
- **Unique:** Verifying monitoring technologies in high permeability reservoir (average 425-1175 mD)
- **CO<sub>2</sub> Source:** Lost Cabin/Madden Gas Plant operated by ConocoPhillips
- **CO<sub>2</sub> Transportation:** Denbury's 232 mile Greencore Pipeline
- **Status:** >360,000 metric tons injected to date

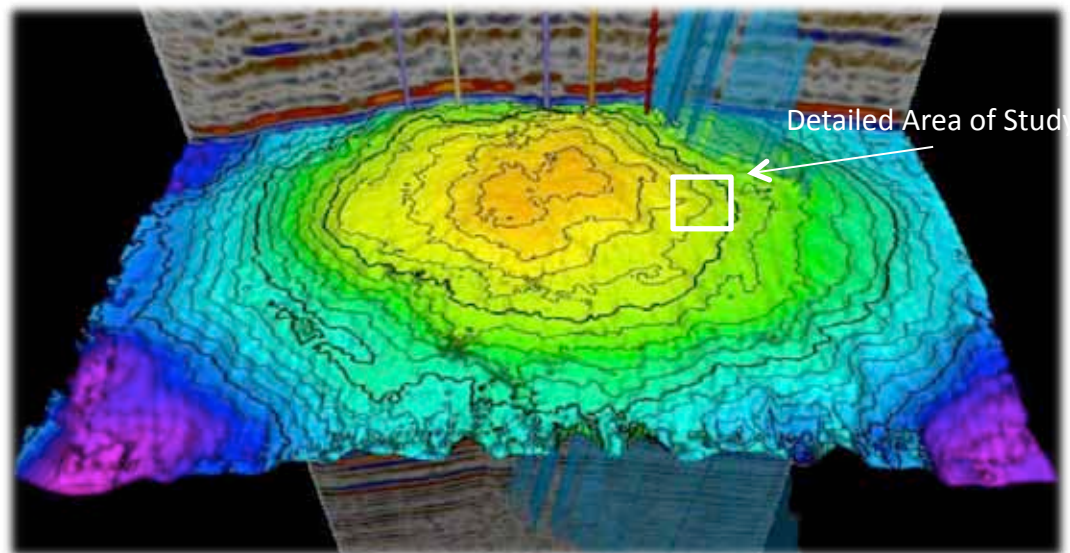
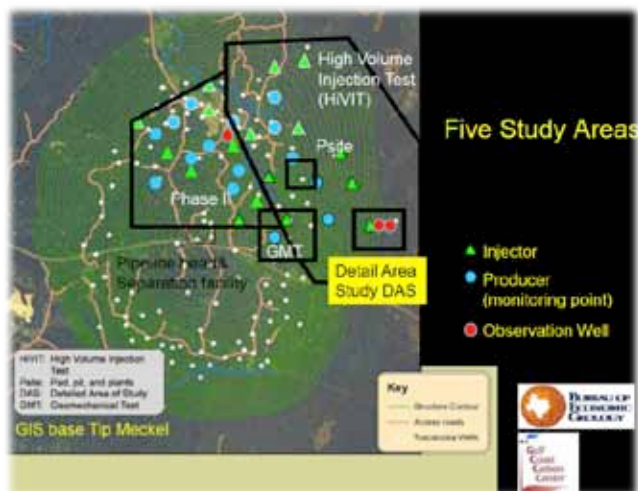




# Southeast Regional Carbon Sequestration Partnership

## *Cranfield (Early Test) Field Project*

- **Target Formation:** Tuscaloosa Formation
- **Depositional Environment:** Fluvial/valley fill
- **Unique:** 1<sup>st</sup> U.S. and 5<sup>th</sup> worldwide project to reach 1 million metric tons of injection
- **CO<sub>2</sub> Source:** Jackson Dome
- **CO<sub>2</sub> Transportation:** Sonat Pipeline to Cranfield operated by Denbury Resources
- **Status:** >3,900,000 metric tons injected to date

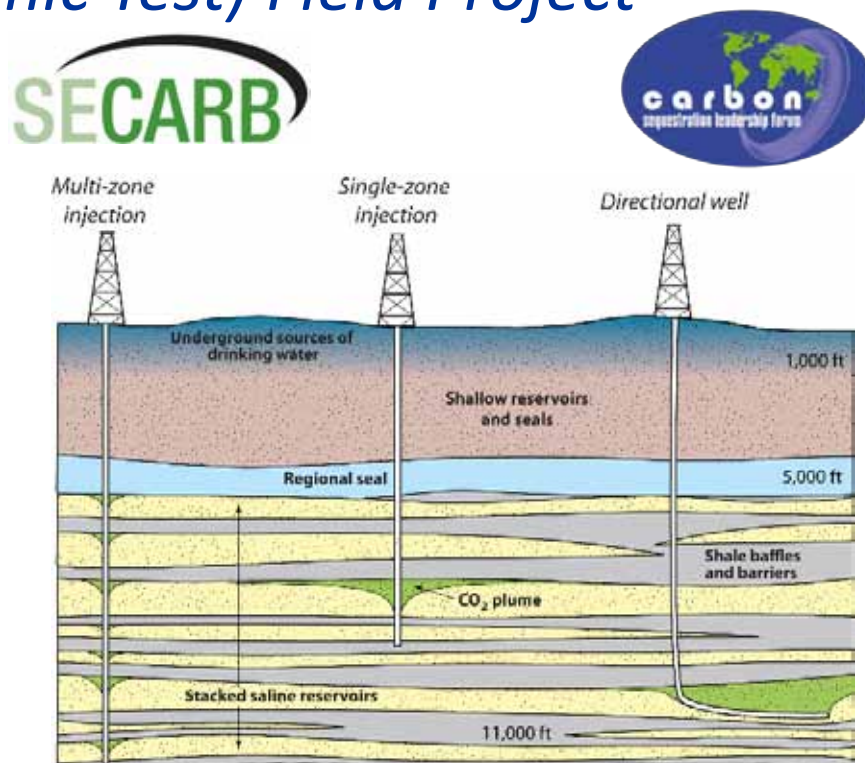


Seismic interpretation  
of Cranfield Dome

# Southeast Regional Carbon Sequestration Partnership

## *Citronelle (Anthropogenic Test) Field Project*

- **Target Formation:** Paluxy Formation
- **Depositional Environment:** Fluvial Deltaic/ Shallow Marine clastics
- **Unique:**
  - Testing the CO<sub>2</sub> flow, trapping, and storage mechanisms of a regionally extensive Gulf Coast saline formation
  - Demonstrating a fully integrated source to sink system reflecting real world conditions
- **CO<sub>2</sub> Source:** Plant Barry's coal-fired generation plant
- **CO<sub>2</sub> Transportation:** 12-mile pipeline
- **Status:** >100,000 metric tons injected to date



Power Plant



Capture



Transport



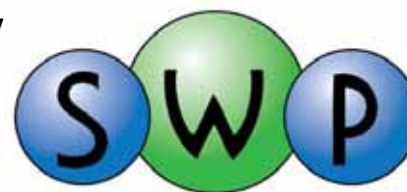
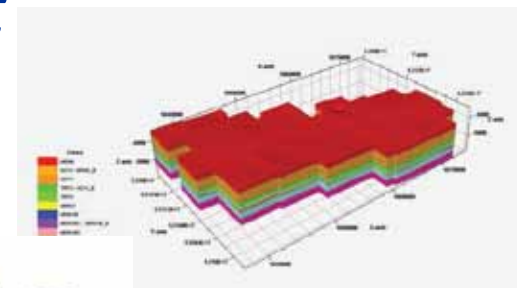
Storage



# Southwest Regional Partnership on Carbon Sequestration

## *Farnsworth Unit Field Project*

- **Target Formation:** Morrow Sandstone
- **Depositional Environment:** Fluvial Deltaic Clastics
- **Unique:** Verifying storage capacity, mechanisms and permanency in a regionally significant incised valley fill sandstone
- **CO<sub>2</sub> Sources:**
  - Agrium (Fertilizer Plant) – Borger TX
  - Arkalon (ethanol plant) – Liberal KS
- **CO<sub>2</sub> Transportation:** Chaparell Energy Pipelines
- **Status:** >37,000 metric tons injected to date



# Regional Carbon Sequestration Partnerships

## *Large-Scale Geologic Tests/Key industry Partners*

RCSP	Performer	Key Industry Partners	Injection Location	Reservoir/Geologic Province	Amount of CO <sub>2</sub> – tonnes	CO <sub>2</sub> Source	Status
<b>Big Sky</b>	Montana State U.	Vector Oil & Gas Ltd Schlumberger Bison Eng.	Kevin, MN	Saline/Kevin Dome – Duperow Formation	1 million over 4 yrs.	Naturally occurring CO <sub>2</sub> produced from Kevin Dome	Drilling of first well to start March-April 2014.
<b>MGSC</b>	Illinois State Geologic Service	Archer Daniels Midland Co. Schlumberger	Decatur, IL	Saline/Illinois Basin – Mt. Simon Sandstone	1 million over 3 yrs.	ADM ethanol fermentation facility	CO <sub>2</sub> injection started Nov. 15, 2011; >745,000 tonnes injected to date
<b>MRCSP</b>	Battelle Memorial Institute	Core Energy, LLC	Otsego County, MI	EOR/Michigan Basin – Niagaran Reef	1 million over 4 yrs.	Core Energy Natural Gas Processing Plant	CO <sub>2</sub> injection started Feb. 2013; >185,000 tonnes injected to date.
<b>PCOR</b>	UNDEERE	Denbury Resources, Inc. Ramgen Power Systems	Bell Creek, MN	EOR/Powder River Basin – Muddy Sandstone	1 million/yr	ConocoPhillips Lost Cabin Natural Gas Processing Facility, WY	CO <sub>2</sub> injection started May 2013; >359,000 tonnes injected to date
<b>PCOR</b>	UNDEERE	Spectra Energy RPS Group. Plc Alberta Innovates	Fort Nelson, BC	Saline/Horn River Basin – Carbonates	1.3 – 2.0 million/yr of mixed CO <sub>2</sub> /H <sub>2</sub> S	Spectra Energy's Fort Nelson Gas –Processing Facility	Planned 2016 start. Reservoir data being collected.
<b>SECARB</b>	SSEB	Denbury Onshore LLC Schlumberger BEG, U. of Texas Sandia Technologies	Cranfield, MS	Saline/Gulf Coast – Tuscaloosa Formation	1.5 million originally planned	Naturally occurring CO <sub>2</sub> produced from Jackson Dome	>3.9 million tonnes injected to date
<b>SECARB</b>	SSEB	EPRI Denbury Onshore LLC Alabama Power Southern Co.	Citronelle, AL	Saline/Gulf Coast – Paluxy Formation	250,000 over 2 years	Southern Company's Plant Barry Power Station	CO <sub>2</sub> injection started August 20, 2012; >100,000 MT injected to date.
<b>SWP</b>	New Mexico Institute of Mining & Technology	Chaparral Energy LLC Schlumberger ARI	Farnsworth, TX	EOR/Anadarko Basin – Morrow Sandstone	1 million over 5 yrs.	Fertilizer Plant - Borger, TX and Ethanol Plant – Liberal, KS	Monitoring of injected CO <sub>2</sub> in the main west Farnsworth Unit > 37,000 MT to date.

# CCS Best Practices Manuals

*Critical Requirement for Significant Wide Scale Deployment-  
Capturing Lessons Learned*



Best Practices Manual	Version 1 (Phase II)	Version 2 (Phase III)	Final Guidelines (Post Injection)
Monitoring, Verification and Accounting	2009/ <b>2012</b>	2017	2020
Public Outreach and Education	2009	2016	2020
Site Characterization	2010	2016	2020
Geologic Storage Formation Classification	2010	2016	2020
**Simulation and Risk Assessment	2010	2017	2020
**Carbon Storage Systems and Well Management	2011	2017	2020
Terrestrial	2010	<b>2016 – Post MVA Phase III</b>	

*\*\*Regulatory Issues are addressed within various Manuals*

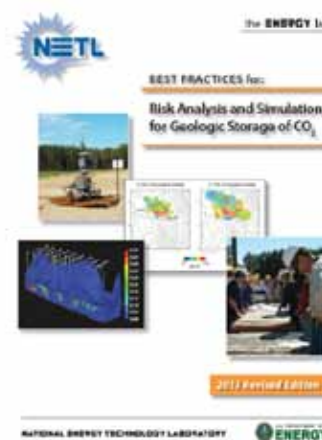
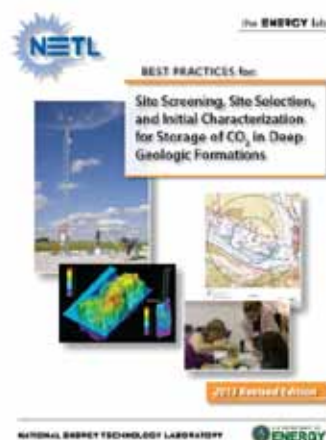
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# CCS Best Practices Manuals

## *Critical Requirement for Significant Wide Scale Deployment- Capturing Lessons Learned*

- 2012 - Sen. Bingaman requested DOE to study induced seismicity through the National Research Council (NRC) to look at induced seismicity during the injection of fluids related to energy production.
- DOE's BMP's have been updated to reflect the findings and recommendations of the NRC study titled "Induced Seismicity in Energy Technologies"
  - Geothermal energy
  - Conventional oil and gas development (including EOR)
  - Shale gas recovery
  - CCS





# Focus Area for Carbon Sequestration Science

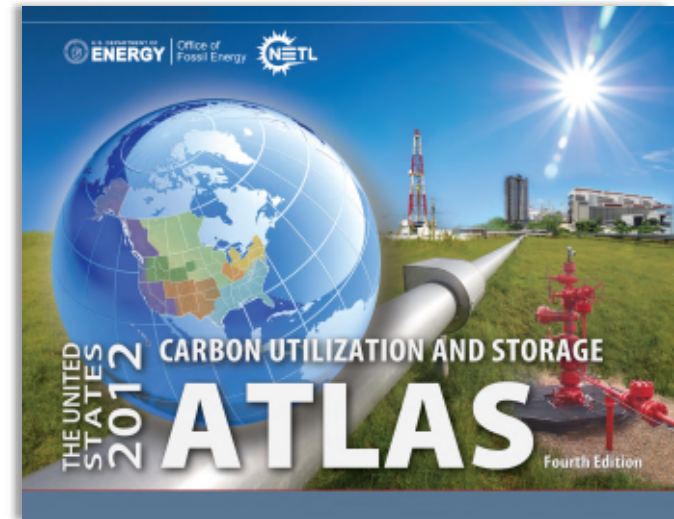
## *U.S. 2012 Carbon Utilization and Storage Atlas (Atlas IV)*

### Released in December 2012

- Updated CO<sub>2</sub> stationary source emission estimates and storage potential of various geologic storage types:
- Outlines DOE's Carbon Storage Program
- Showcases updated info about Regional Carbon Sequestration Partnership (RCSP) CO<sub>2</sub> storage activities
- New information from the ARRA Site Characterization projects
- Highlights CCS collaborations and worldwide CCS projects

### Atlas V scheduled for release in July 2015

- Introduction of organic shale capacity estimate method
- Slight changes in format to highlight injection projects



Atlas I - March 2007

Atlas II - November 2008

Atlas III - November 2010

# Carbon Storage Program

## *Collaborating to Address Technical Issues*

### **Global Collaborations**

- Leveraging Expertise with International CCS Projects
- IEAGHG R&D Program
- Carbon Sequestration Leadership Forum
- London Convention/London Protocol
- North American Carbon Atlas Partnership
- U.S.-China Clean Energy Research Center



### **Focus Area for Carbon Sequestration Science**

- National Carbon Sequestration Database (NATCARB)
- Energy Data Exchange
- Research on Storage Reservoirs, Seal Integrity, MVA technologies, Computational and Experimental Methods, CO<sub>2</sub> Utilization

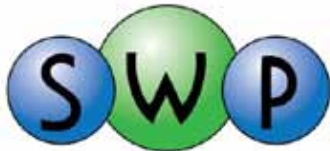
### **Supporting Mechanisms**

- Interagency and State Coordination
- ARRA Site Characterization and CCS Training Centers
- Systems and Benefits Analysis
- University and Research Laboratory Collaboration

# Knowledge Sharing



- Annual RCSP Meeting
- RCSP Working Groups
- Domestic/International Collaborations
- Technical Workshops
- Domestic/International Conferences
- Training-IEAGHG CCS Summer School, RECS Summer Program



**Thank you.  
Questions ?**

