SECARB-ED
Southeast Regional Carbon Sequestration Technology Training Program

CCS Capacity Building Workshop

SECARB's Regional Projects and Training Activities

Presented by:
Gerald R. Hill, Ph.D.
Southern States Energy Board

October 25, 2011
Columbia Gas Transmission Building
Charleston, WV

SOUTHERN STATES ENERGY BOARD

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Acknowledgements

- SECARB-Ed is supported by the U.S. Department of Energy's (DOE) National Energy Technology Laboratory as part of the American Recovery and Reinvestment Act of 2009 under DE-FE0001930.
  - www.netl.doe.gov/technologies/carbon_seq/arra/training.html
- The Southern States Energy Board is the Principal Contractor of SECARB-Ed to DOE.
  - http://www.secarb-ed.org/
- Cost share and research support is provided by SECARB/SSEB Carbon Management Partners.
- The CO_2 Capture Unit at Plant Barry is funded separately by Southern Company and partners.

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Outline

- **Overview**
- **Coal Seams: ECBM and Storage**
- **Early Test: EOR and Storage**
- **Anthropogenic Test: Capture, Transportation, and Storage Integration**

E-Alerts, Newsletters & Webpage

Quarterly Training Newsletter and E-Alert:

- Summary of upcoming training opportunities
- Material of a technical nature relevant to the SECARB-Ed region
- Results from on-going CCS research
- Public policy updates related to CCS
- Alerts to forthcoming R&D solicitations

Webpage

- www.SECARB-Ed.org

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Research Experience in Carbon Sequestration (RECS)

Plant Barry & Citronelle, Alabama – June 2011

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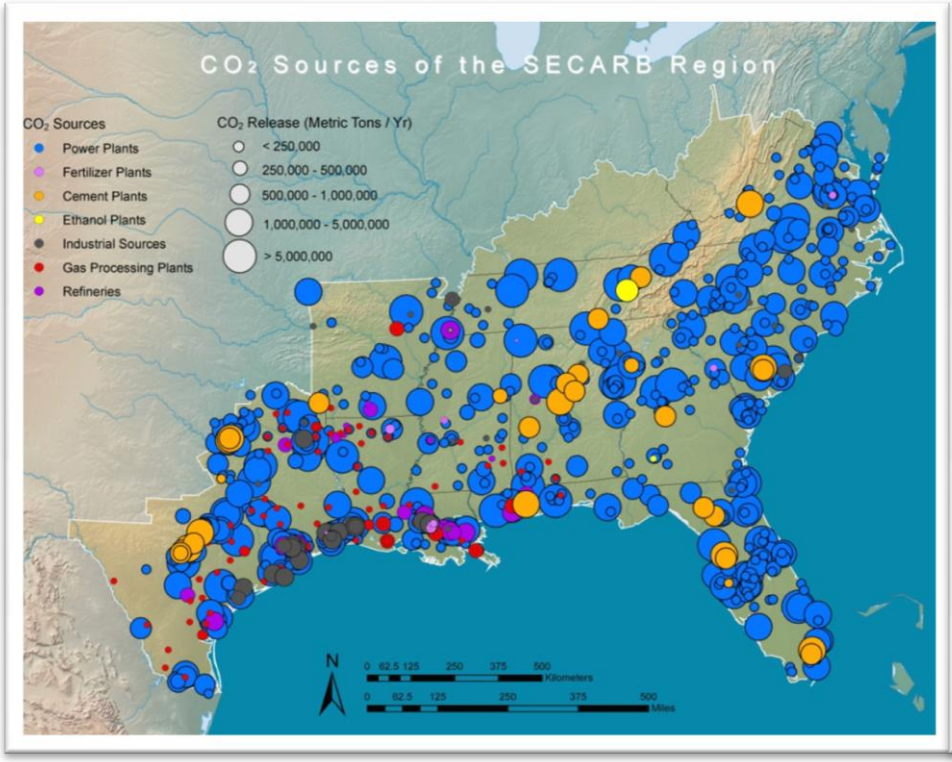
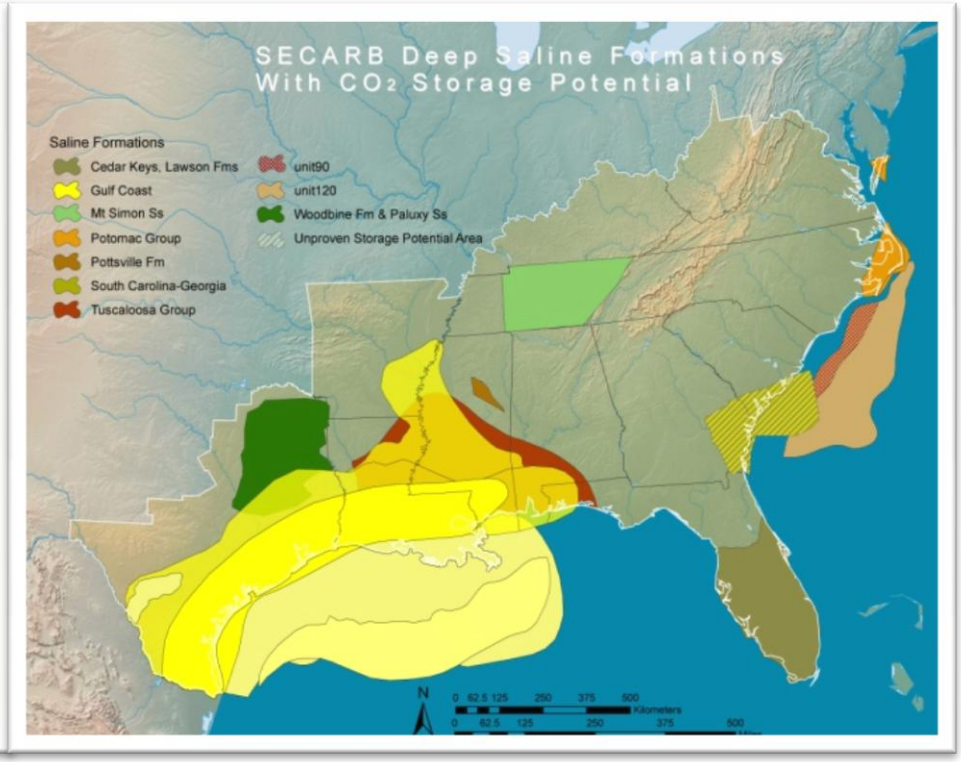
enTech
JACKSON SCHOOL OF GEOSCIENCES
VirginiaTech

SECARB Phase I Characterization: CO_2 Sources & Geologic "Sinks"





SECARB Phase II

All Validation Projects Successfully Completed

VirginiaTech
Invent the Future

Coal Seam Project
Host Company: CNX Gas
Russell County, Virginia

GEOLOGICAL SURVEY OF ALABAMA
Founded 1848

Coal Seam Project
Host Company: El Paso E&P
near Tuscaloosa, Alabama

Characterization for Large-Volume CO_2 Storage Options

MARSHALL MILLER & ASSOCIATES

Stacked Storage Project
Cranfield Test Site
Host Company: Denbury Resources, Inc.
near Natchez, Mississippi

Gulf Coast Carbon Center

Mississippi Test Site
Mississippi Power's Plant Daniel
Escatawpa, Mississippi

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Another CCUS Option: Enhanced Coal Bed Methane (ECBM) Production Combined with CO_2 Storage

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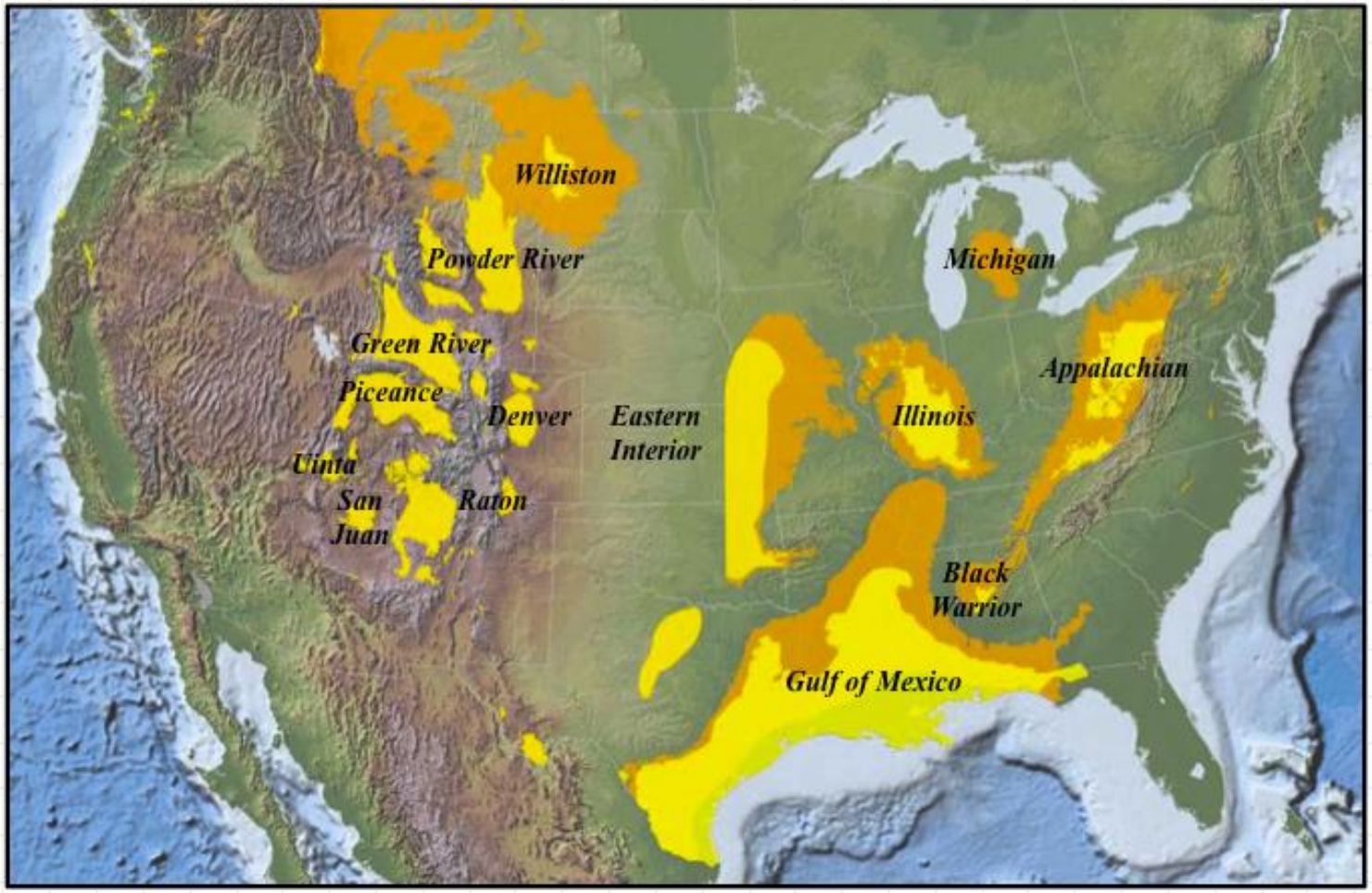
Major U.S. Coal Basins
Coal capacity ~65-128 Gt CO_2
Shale capacity being assessed



Dual Porosity

Butt Cleats and Face Cleats Facilitate Flow in ECBM Fields

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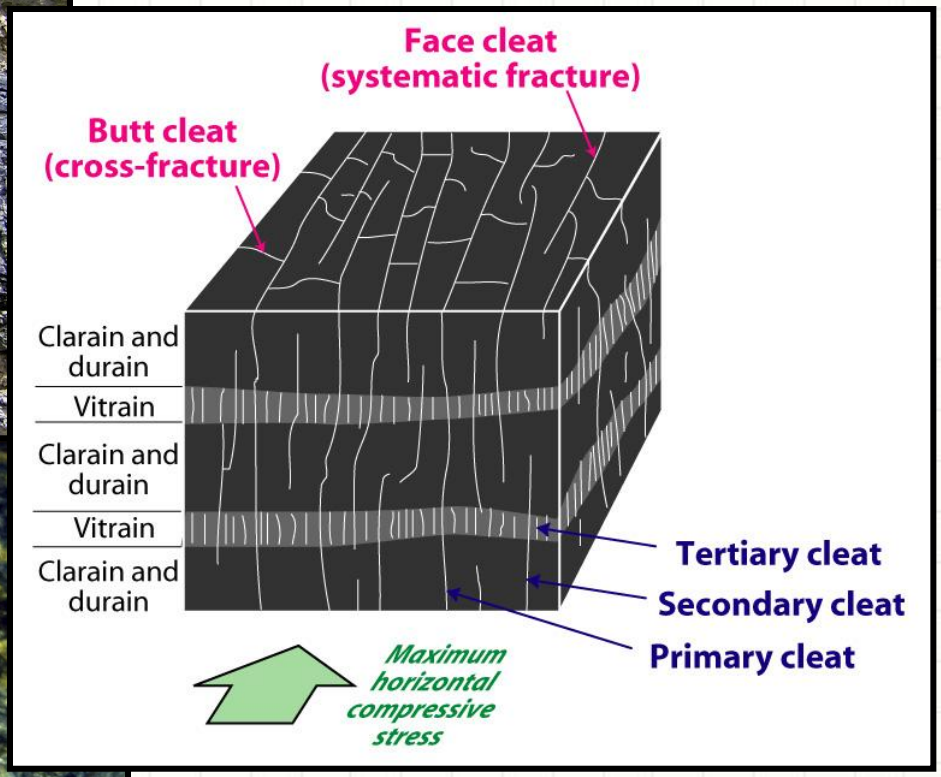
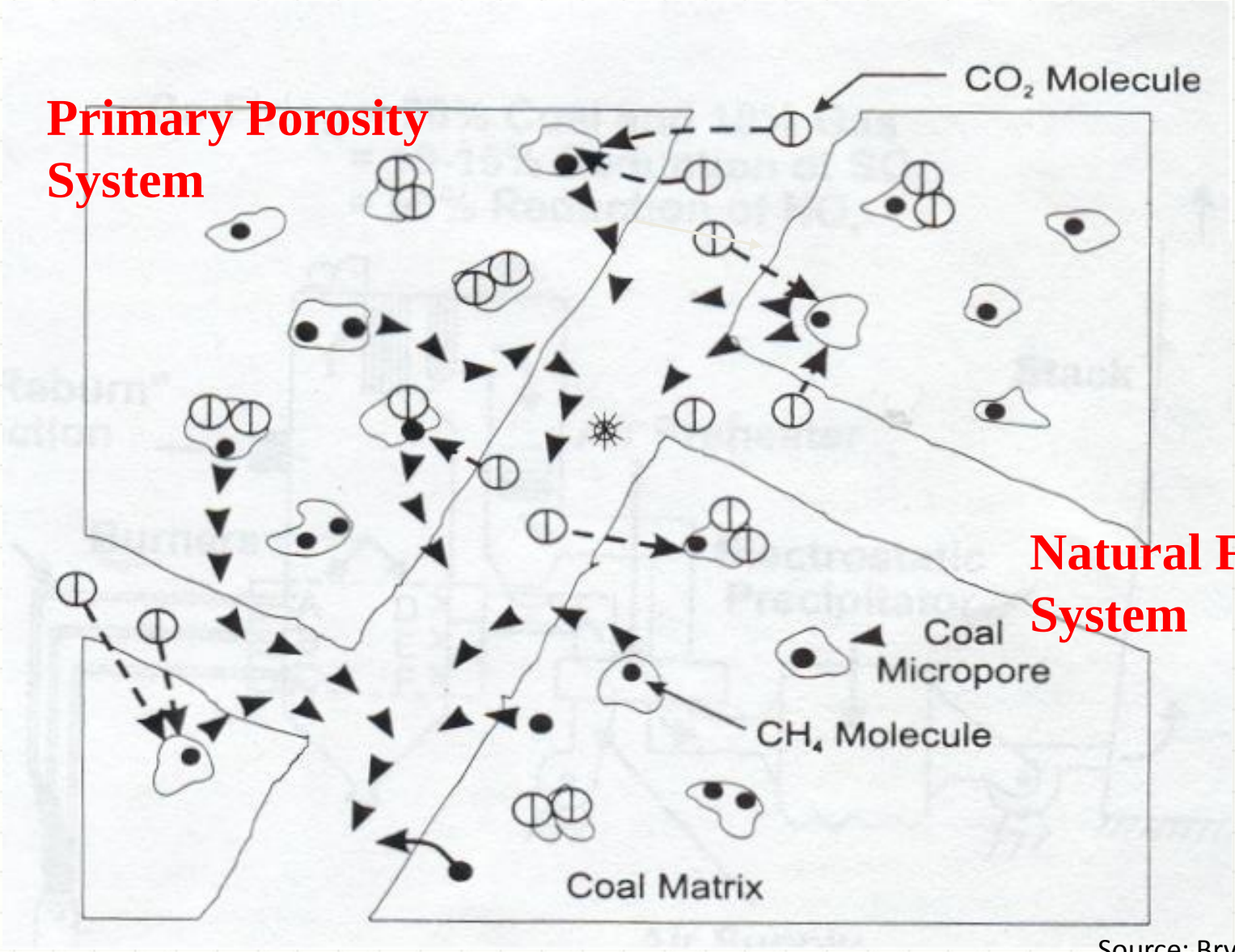
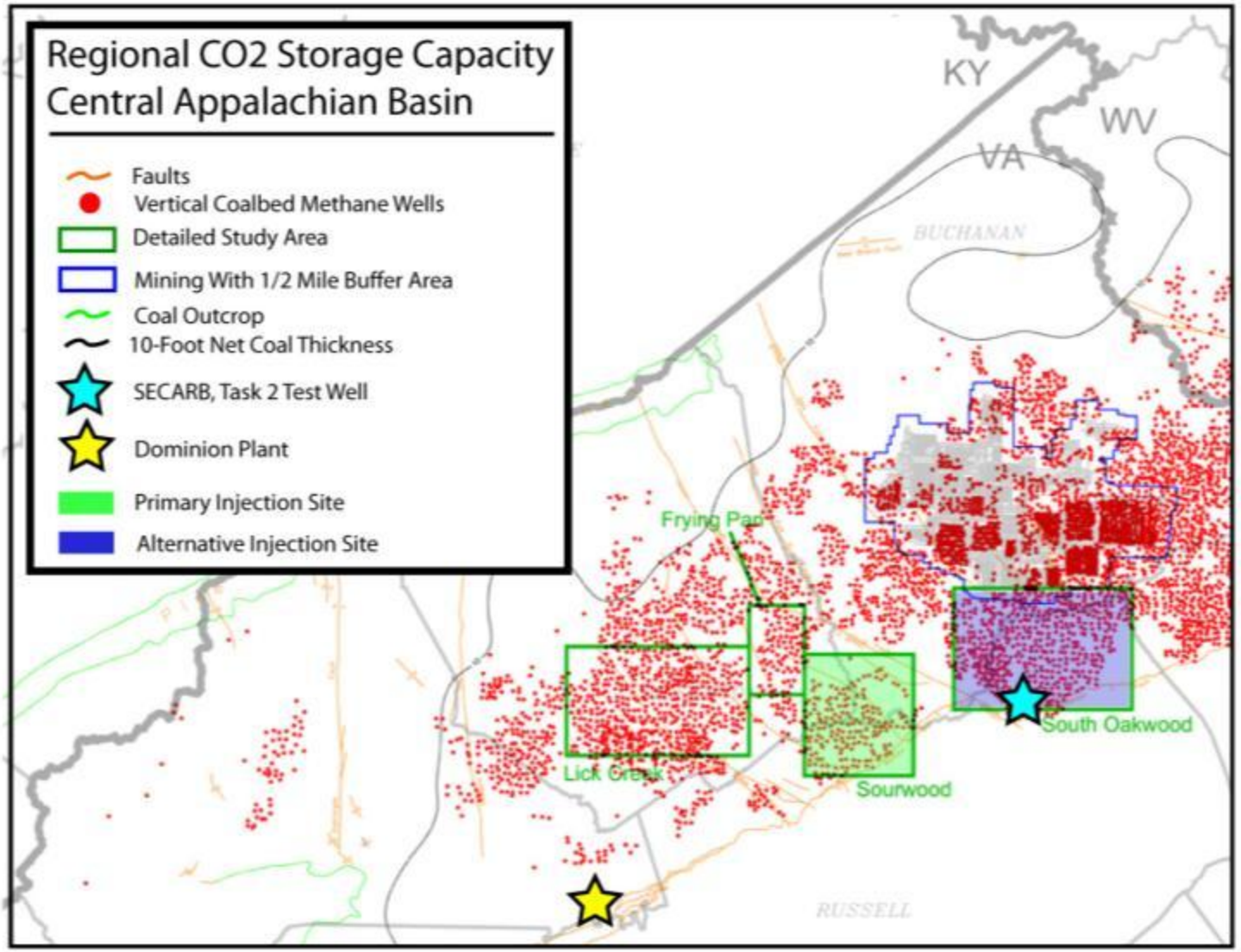


CO_2 – CH_4 Exchange: Injected CO_2 flows via Cleat Systems, Adsorbing to Coal and Desorbing Methane



Source: Bryer, 1999



Virginia Tech: Map of proposed study area

Update on Results of SECARB " Early" Test of Monitoring Large Volume Injection at Cranfield

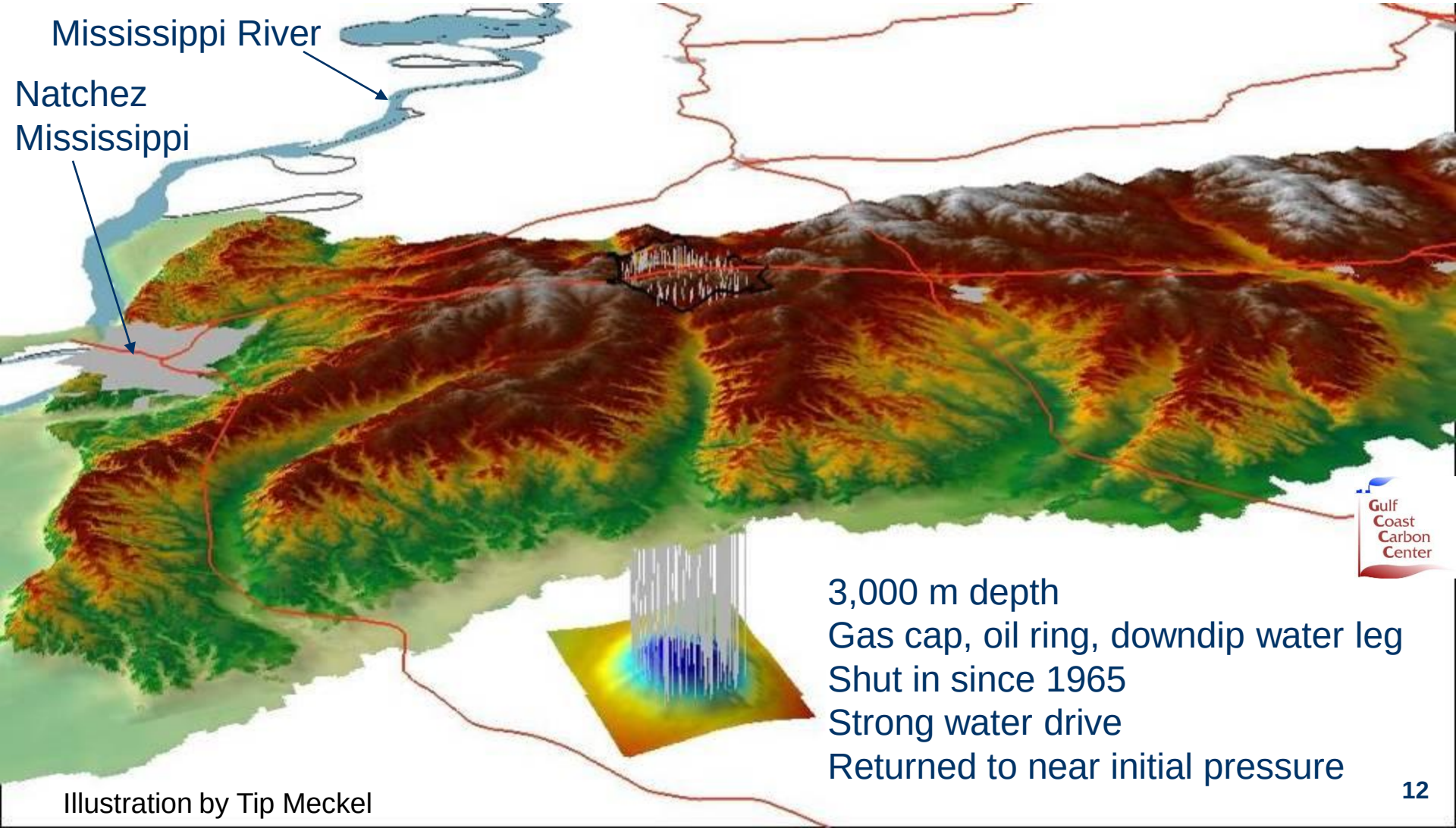
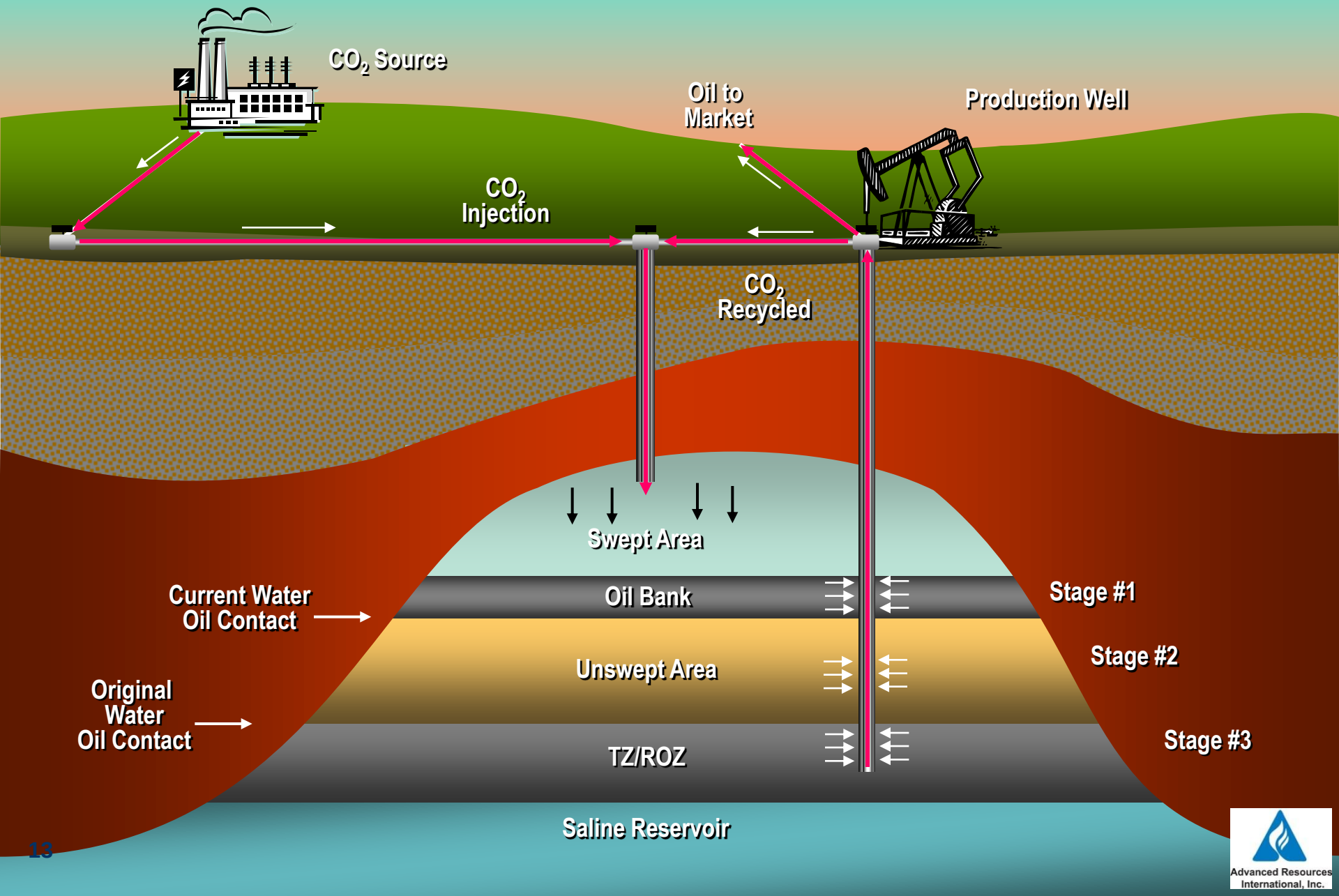


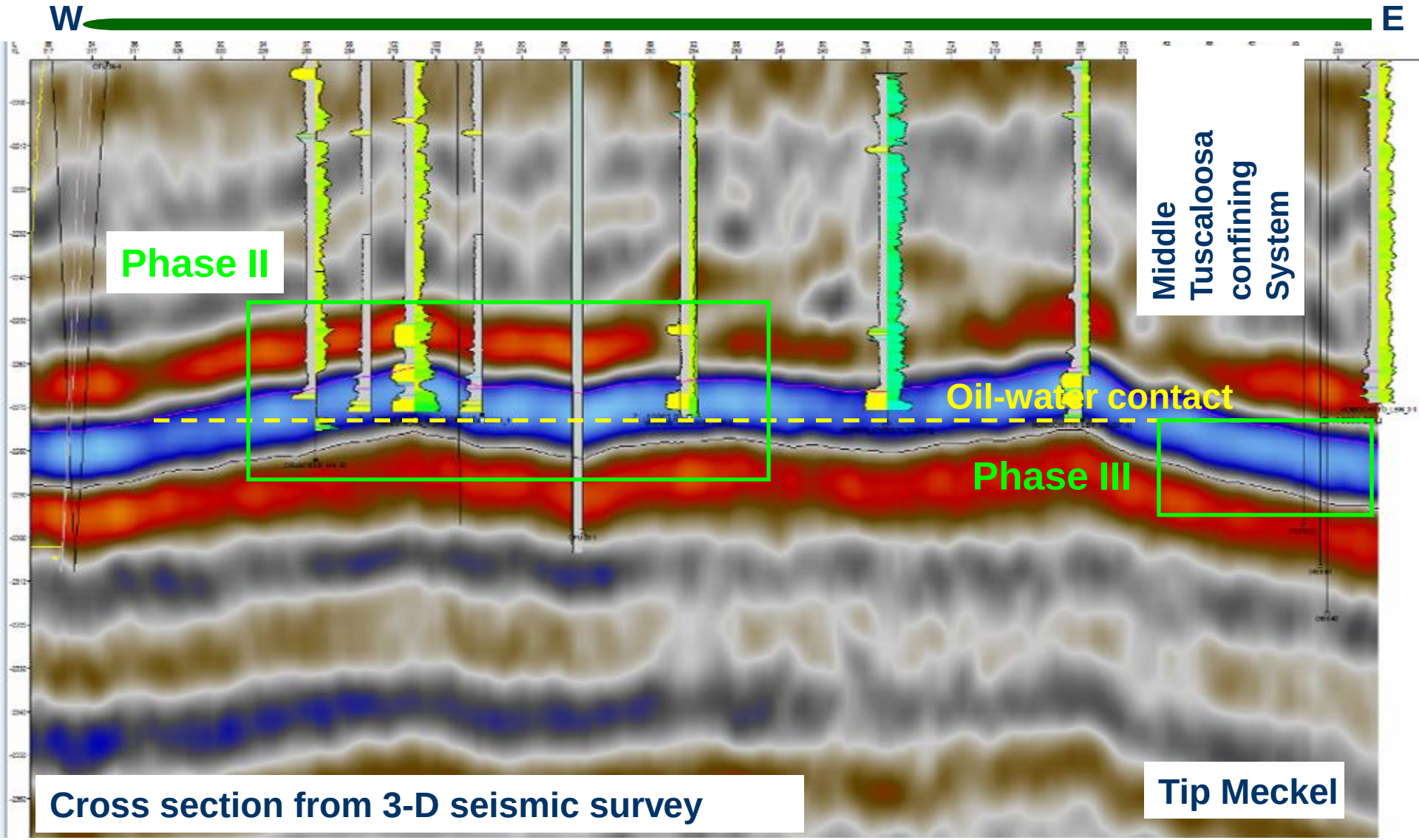
Illustration by Tip Meckel

Integrating CO_2 Utilization and CO_2 Storage (CCUS)



Advanced Resources International, Inc.

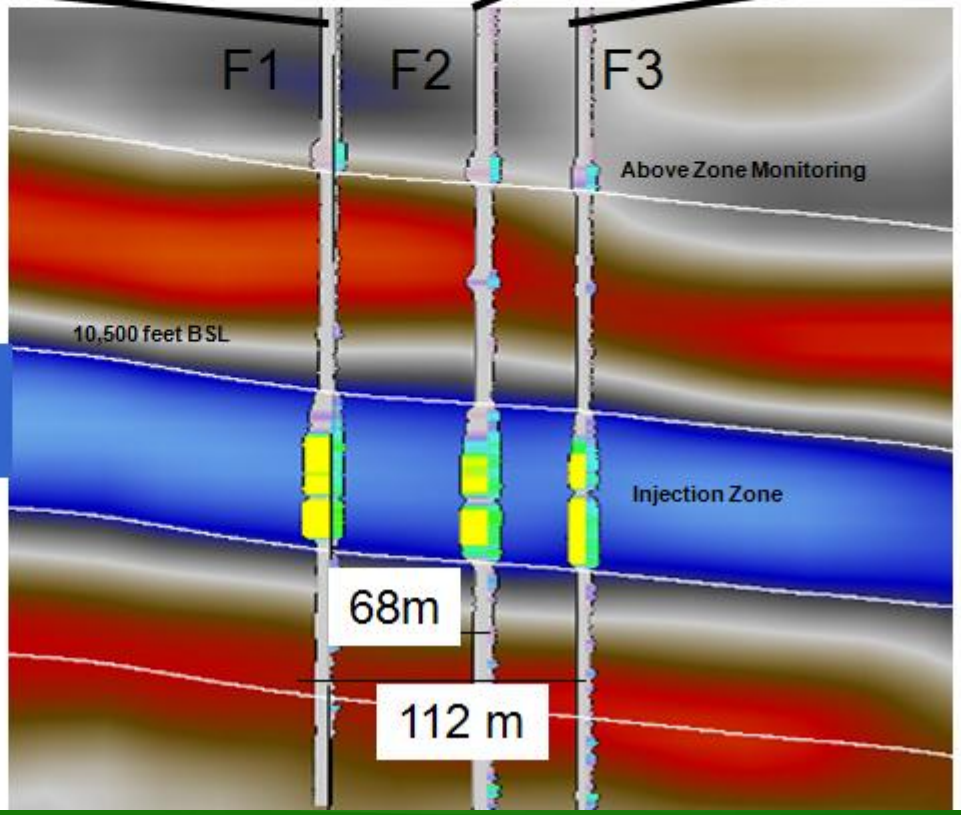
Stacked Reservoirs at Cranfield



Cranfield Early Test Monitoring: Detailed Area of Study

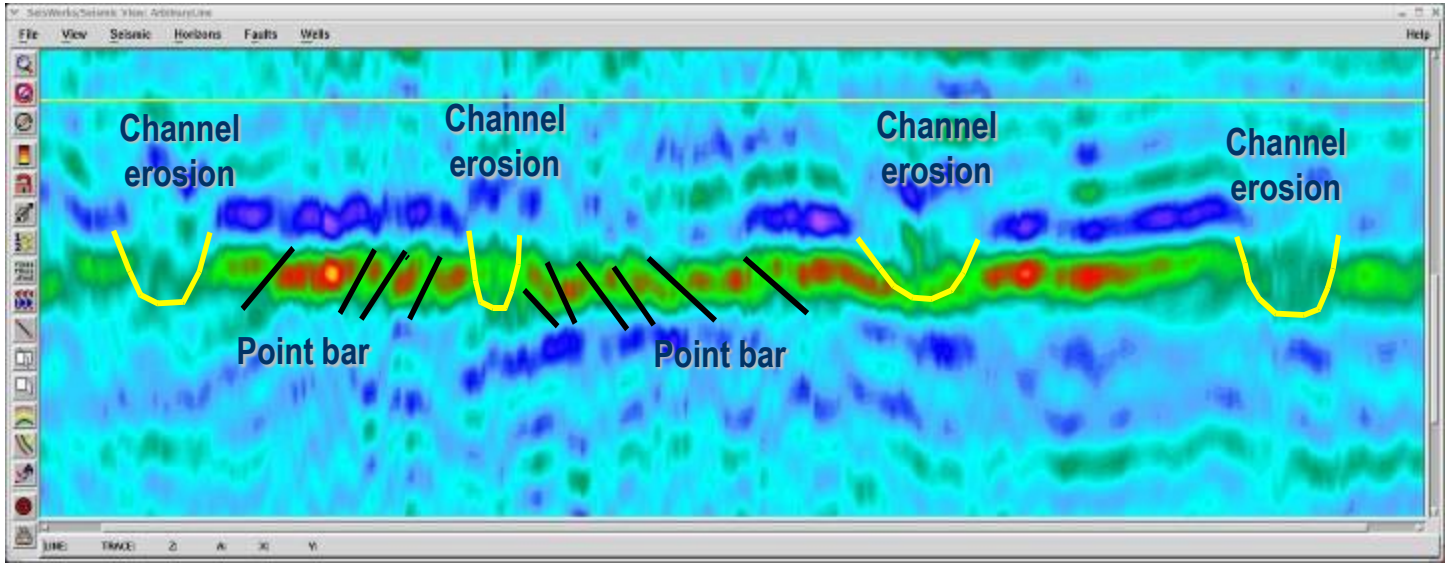
Closely spaced well array to examine flow in complex reservoir

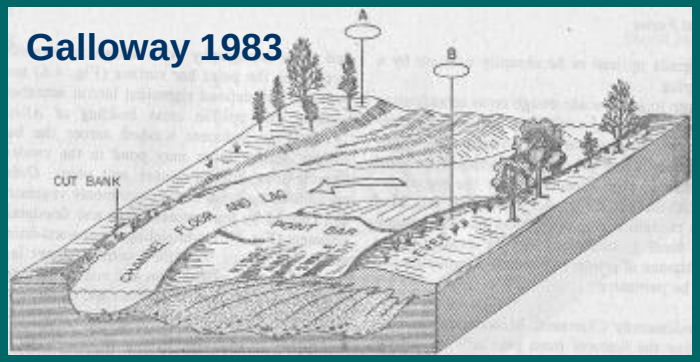
Lower Tuscaloosa injection zone



Gulf Coast Carbon Center

High Quality but Complex Injection Zone

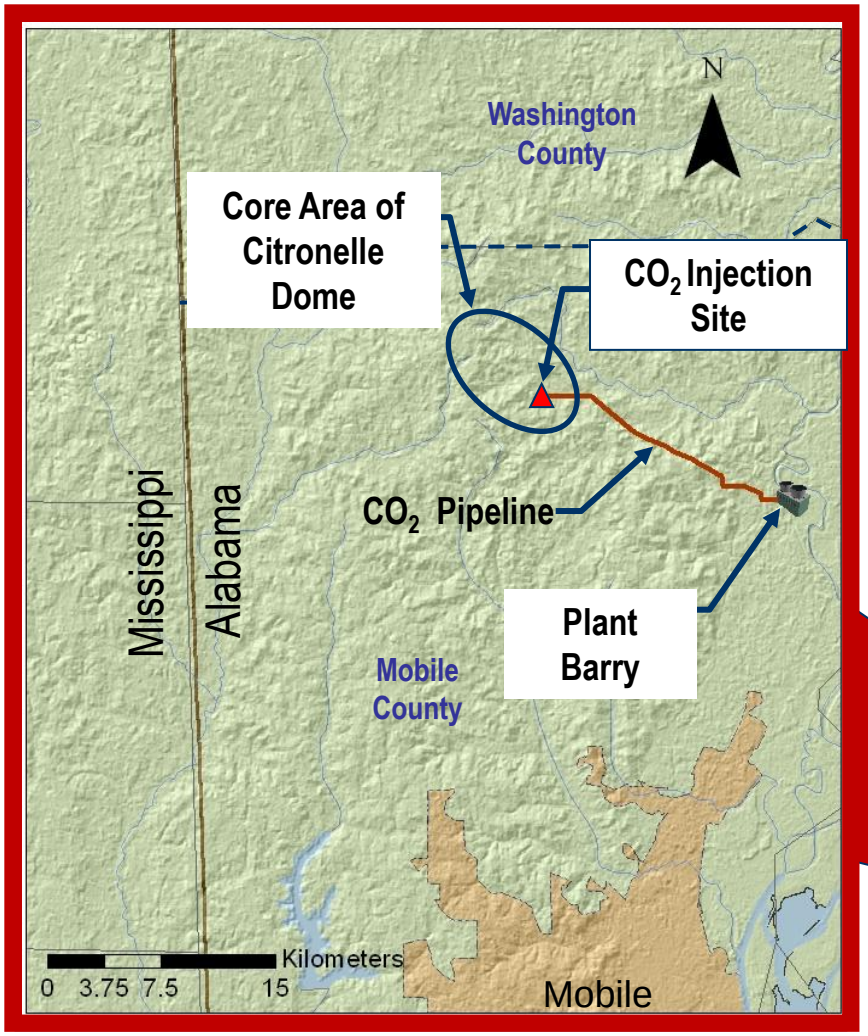




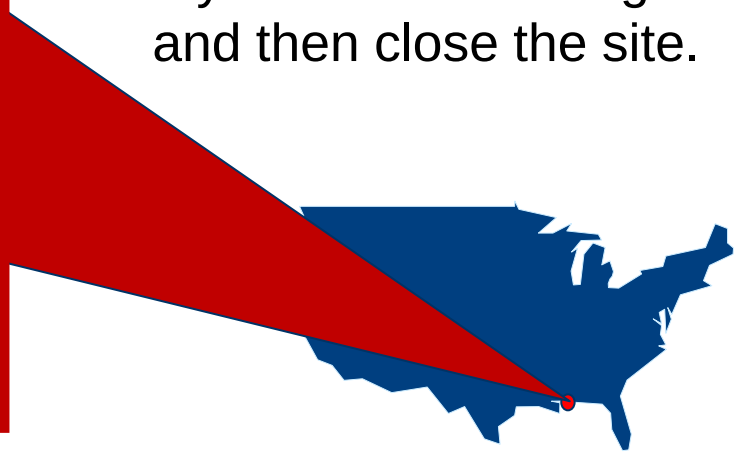
Meander fluvial model

Stratal slicing of 3-D volume
Hongliu Zeng

SECARB Phase III Anthropogenic Test



- 25 MW CO_2 capture unit at Alabama Power's (Southern Company) Plant Barry.
- 12 miles CO_2 pipeline transport from Plant Barry to Citronelle.
- CO_2 injection of 100-300 thousand metric tons into deep saline Paluxy Formation over 2-3 years.
- 3 years of monitoring after injection and then close the site.



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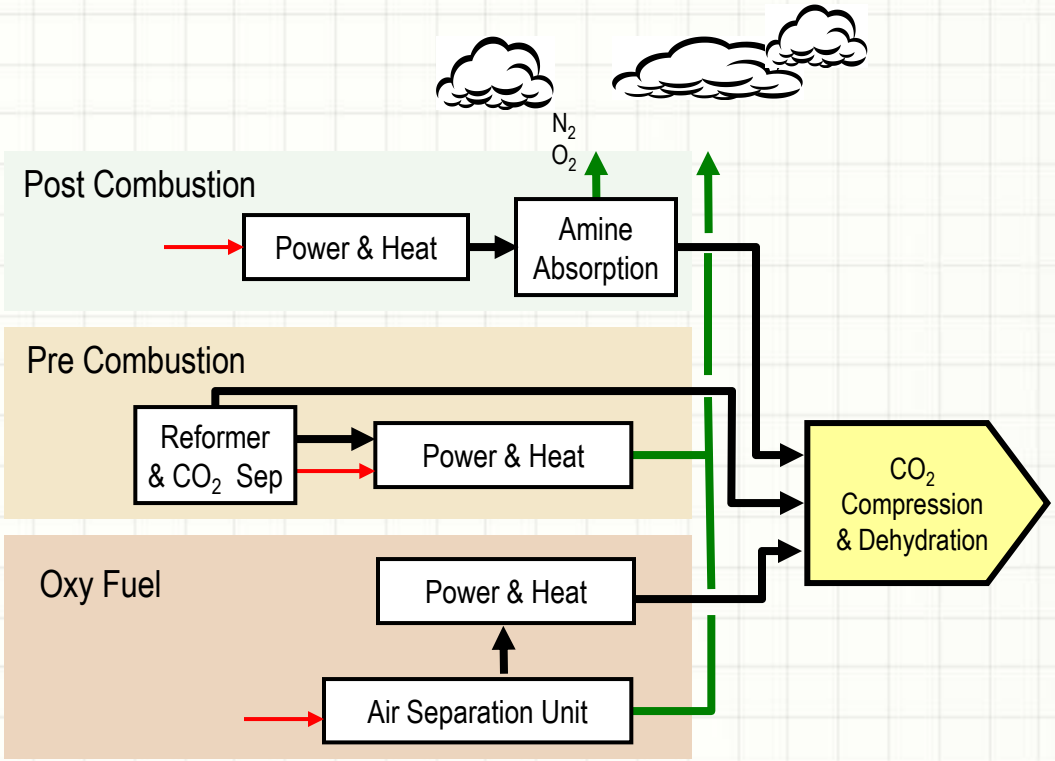
CO_2 Capture
Three General Categories

- Install on new fossil plants or retrofit to existing plants
- Integrated Gas Combined Cycle (IGCC) gasification with carbon capture
- Oxygen enrichment results in concentrated CO_2 stream



Carbon Capture Capable (post combustion example)

Dominion's Virginia City, VA plant currently under construction

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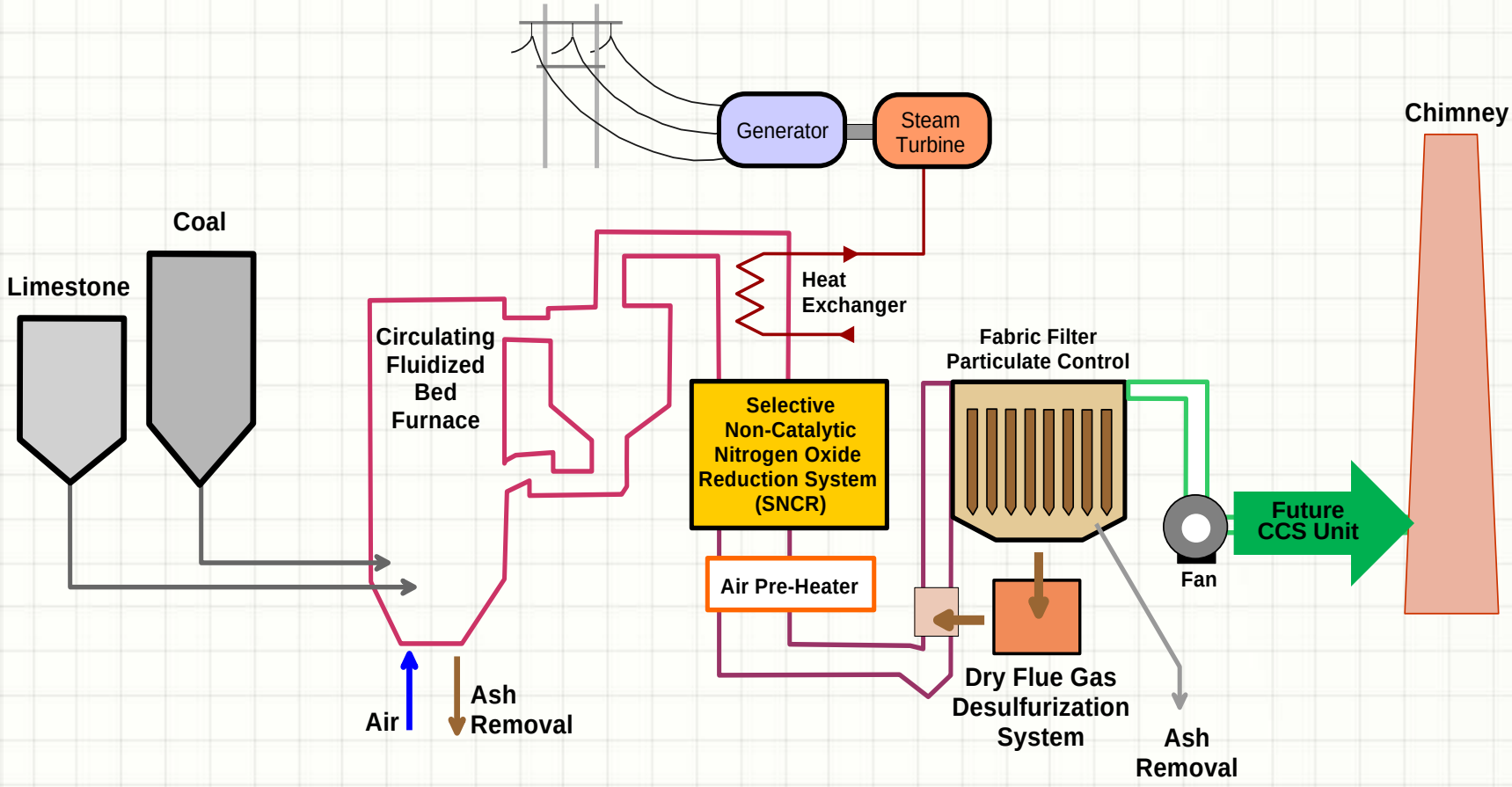
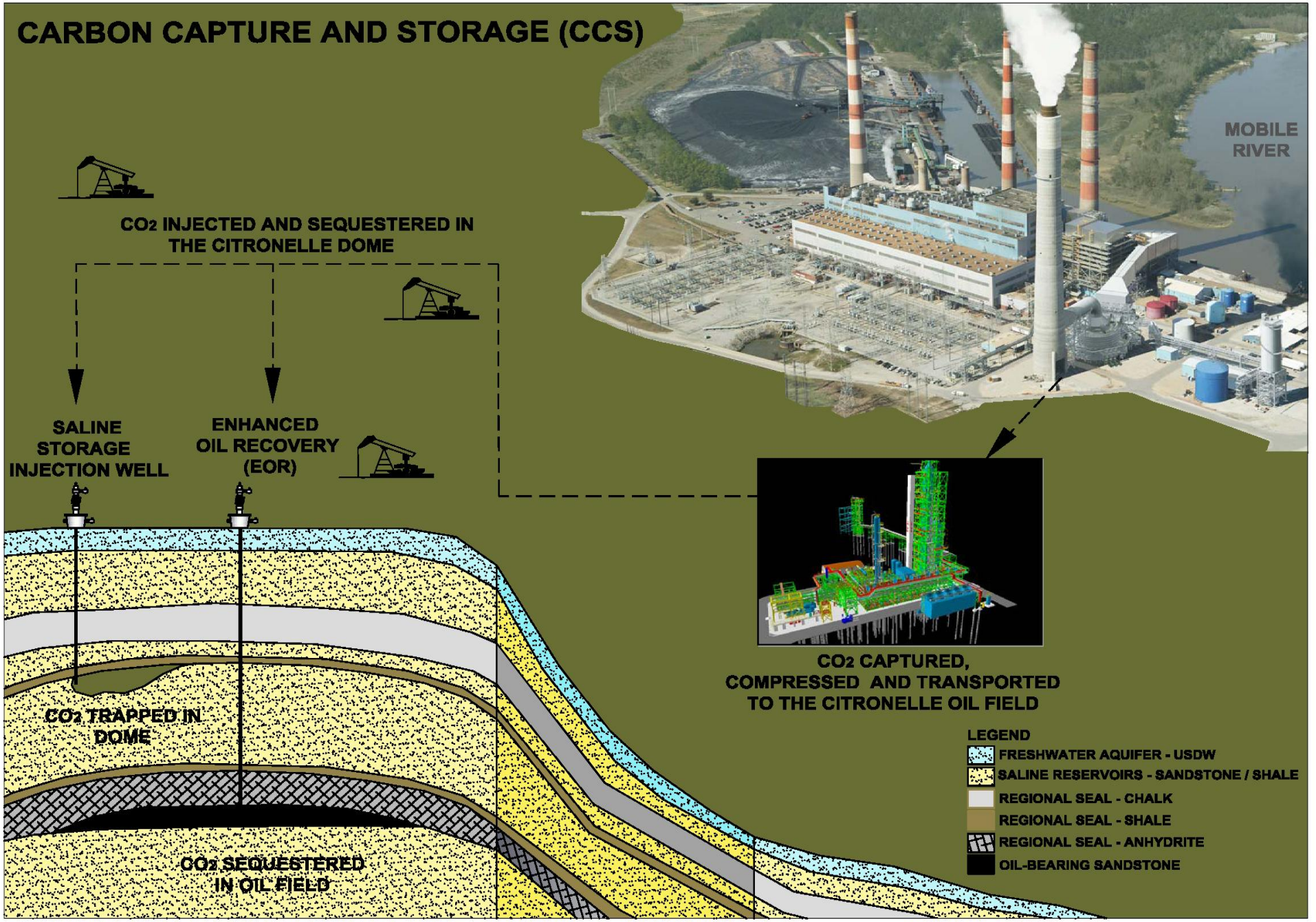
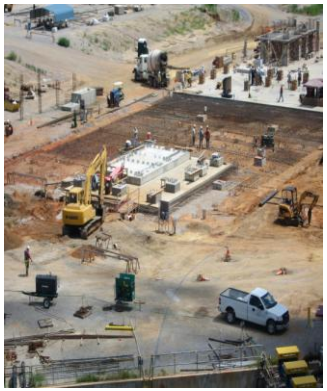




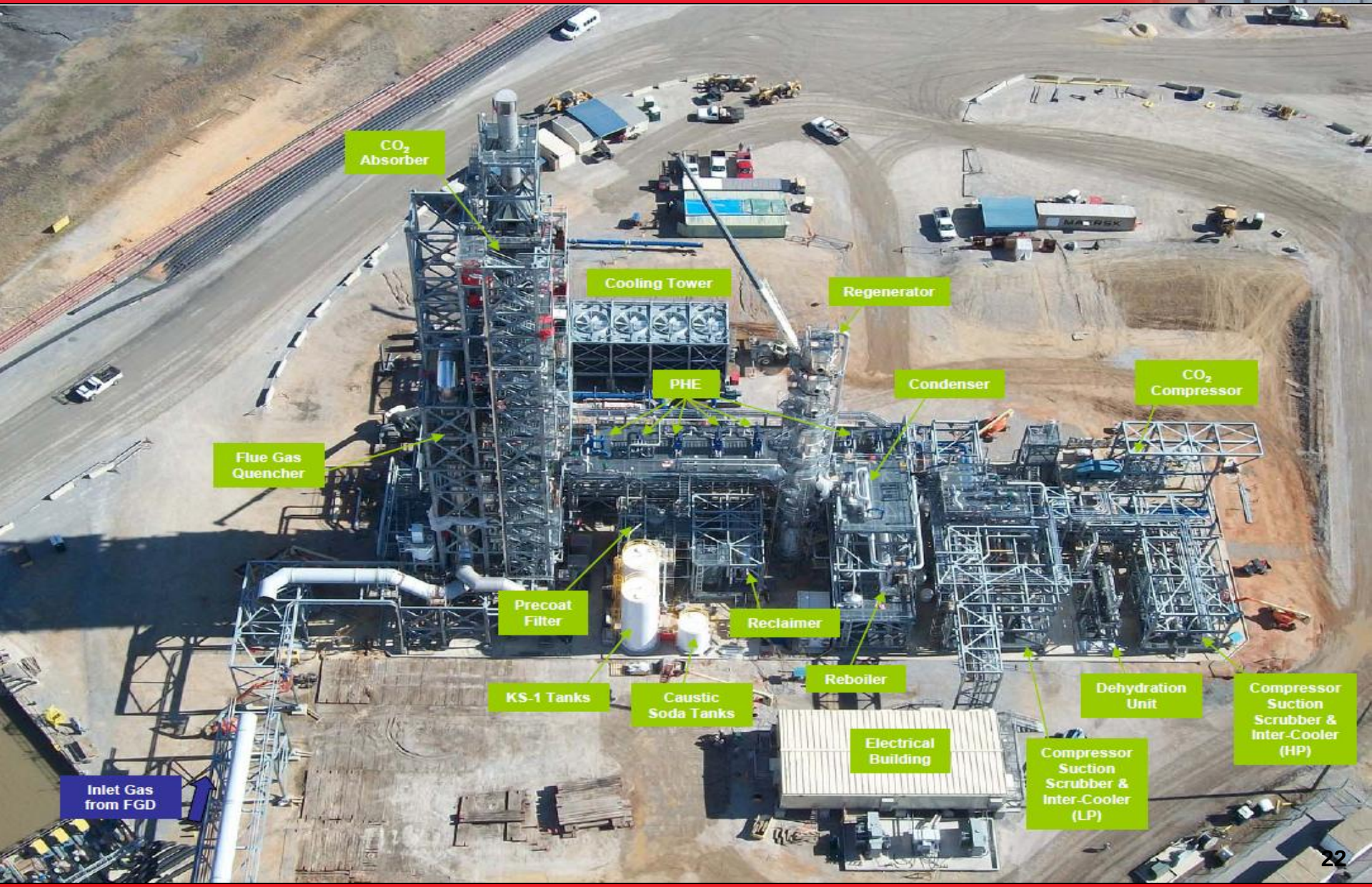
Courtesy: Southern Company

Anthropogenic Test: Plant Barry & Citronelle Field

Capture Facility at Alabama Power's Plant Barry (July 2010 – Present)

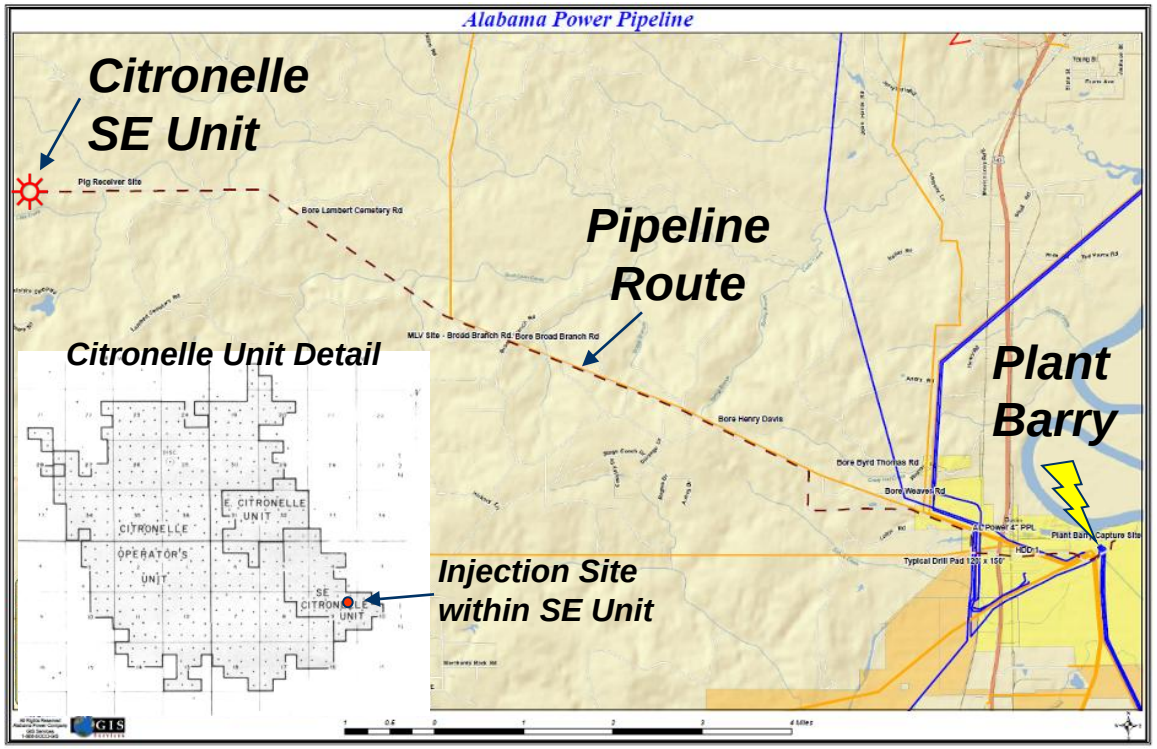


CO_2 Capture Facility – Process Island



CO_2 Pipeline Overview

- Approx. 12 mi to the SE operators unit in Citronelle Field
- Right-of-Way
  - Utility corridor for 80%; 9 land owners
- Pipe specifications
  - 4-in pipe dia.
  - X70 carbon steel
  - DOT 29 CFR 195 liquid pipeline; buried 3 feet with surface vegetation and maintenance
  - Purity is 97% dry CO_2 at 115ºF, 1,500 psig (< 20 ppm H_2S)



- Right-of-way habitat (pine forest in the Mobile River watershed; some wetlands)

Directional drilling required to avoid disturbing Gopher Tortoise habitat

Images Courtesy Southern Company

Anthropogenic Test: Plant Barry & Citronelle Field

Characterization Well D9-8 #2 at Citronelle Field - Drilled (Dec. 2010/Jan. 2011)

- Convert to Obs/Monitoring Well
- 11,800’ TD
- Whole core (98 feet in two intervals)
- 45 sidewall cores
- Full set of logs (Triple Combo, MRI, Mineralogy, Dipole Sonic, CBL, etc.)

Reservoir Characterization

The drilling of the characterization well allowed for local data collection that were used for geologic characterization and subsequent reservoir modeling input data.

Key Data:

- Core from the confining unit(s) and injection interval
  - Permeability, porosity and lithology
  - Capillary pressure
  - CO2 relative perm
- Vertical Seismic Profiling
  - Local structure
  - Plume extent
- Wireline geophysical logging
  - Depth, thickness, porosity, perm, mineralogy, fracture density, and dip
- Pressure transient testing
  - Permeability and completion efficiency

System	Series	Stratigraphic Unit	Major Sub Units		Potential Reservoirs and Confining Zones
Tertiary	Plio-Pliocene		Citronelle Formation		Freshwater Aquifer
	Miocene	Undifferentiated			Freshwater Aquifer
			Chicasawhay Fm.		Base of USDW
	Oligocene	Vicksburg Group	Bucatunna Clay		Local Confining Unit
	Eocene	Jackson Group			Minor Saline Reservoir
		Claiborne Group	Talahatta Fm.		Saline Reservoir
		Wilcox Group	Hatchetigbee Sand		Saline Reservoir
	Paleocene		Bashi Marl		
			Salt Mountain LS		
		Midway Group	Porters Creek Clay		Confining Unit
Cretaceous	Upper	Selma Group			Confining Unit
		Eutaw Formation			Minor Saline Reservoir
		Tuscaloosa Group	Upper Tusc.		Minor Saline Reservoir
			Mid. Tusc.	Marine Shale	Confining Unit
			Lower Tusc.	Pilot Sand Massive sand	Saline Reservoir
Cretaceous	Lower	Washita-Fredericksburg	Dantzler sand		Saline Reservoir
			Basal Shale		Primary Confining Unit
		Paluxy Formation	'Upper' 'Middle' 'Lower'		Proposed Injection Zone
		Mooringsport Formation			Confining Unit
		Ferry Lake Anhydrite			Confining Unit
		Donovan Sand	Rodessa Fm. 'Upper'		Oil Reservoir
			'Middle'		Minor Saline Reservoir
			'Lower'		Oil Reservoir

Confining Zone

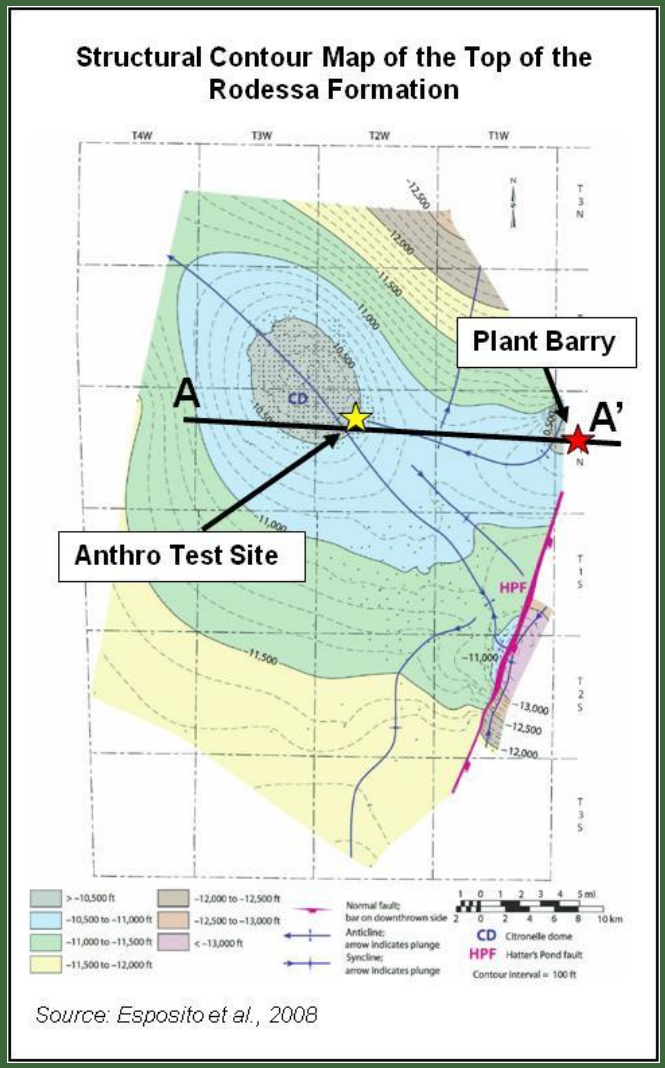
Injection Zone

- Target: Lower Cretaceous Paluxy Fm (at 9,400').
- 1,100 foot interval of stacked sandstones and shales.
- Numerous reservoir seals and confining units.
- No evidence of faulting or fracturing, based on reinterpretation of existing 2D seismic lines.

Citronelle Dome is:

- A subtle open fold
- Limbs dipping less than 1 degree
- Four-way structural closure

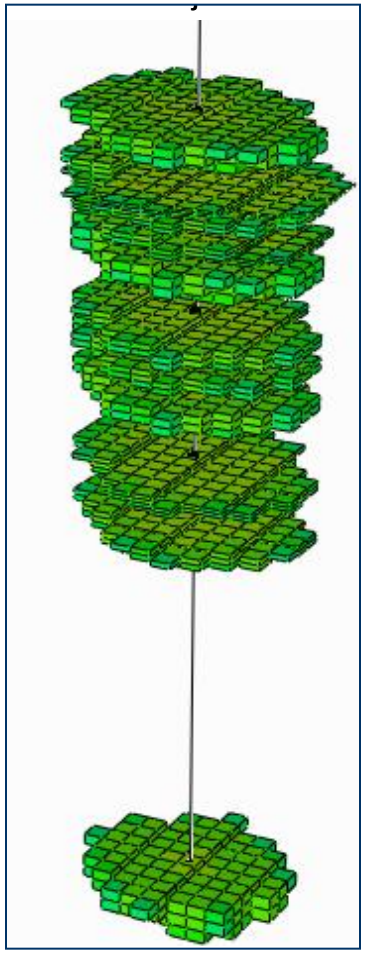
Sources: Pashin et al., 2008; Cottingham, 1988; Esposito and others, 2008



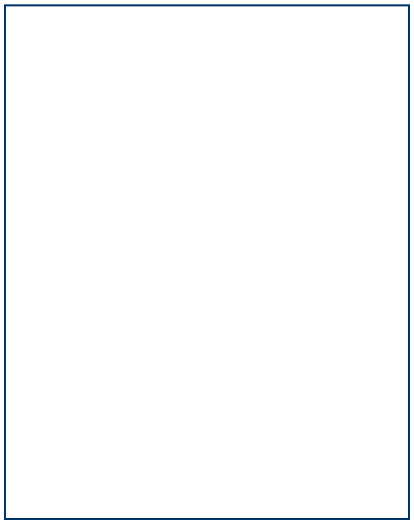
Updating the Geocellular Model

3D View of CO_2 Plume End of Injection

Original Model



Updated Model

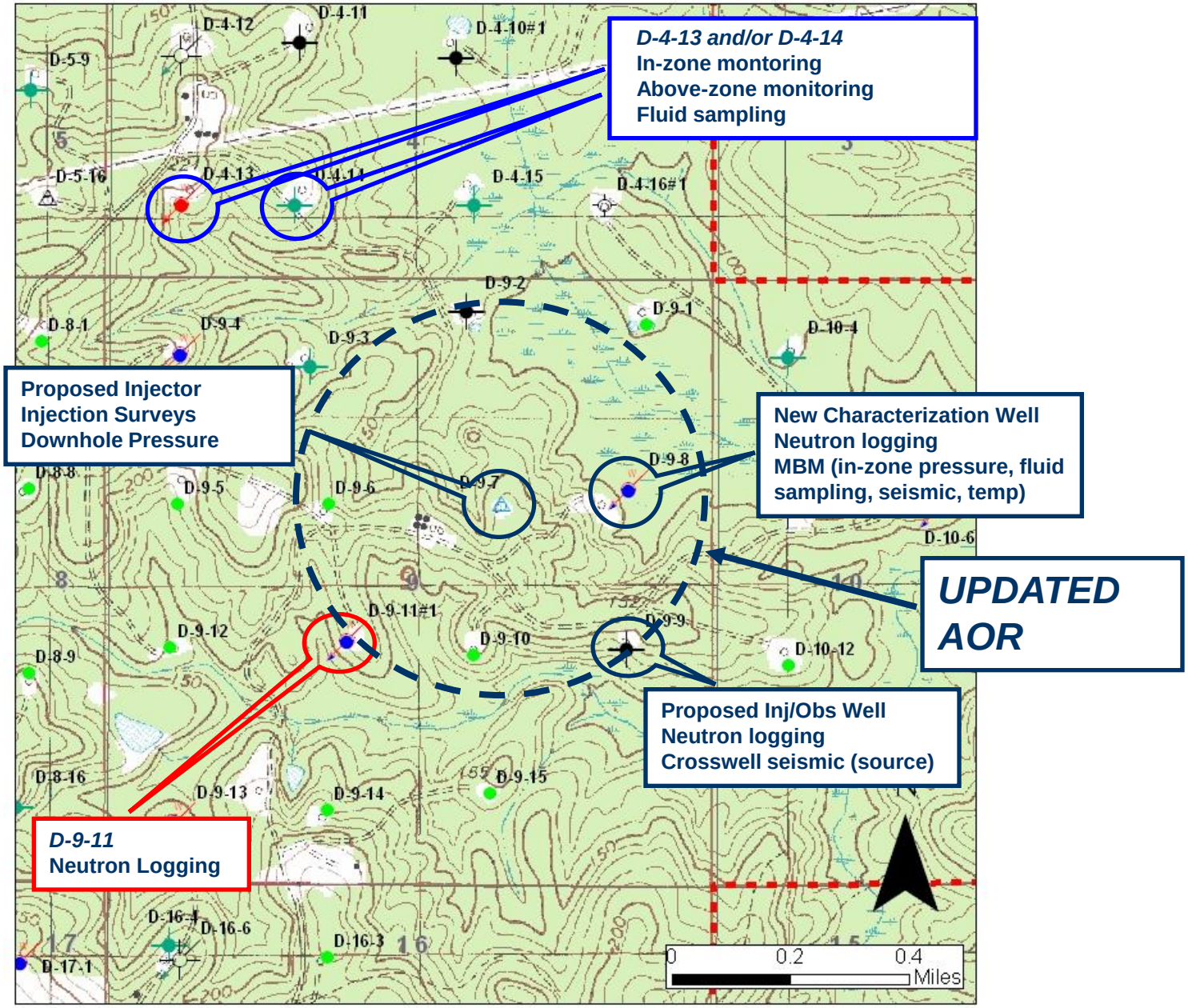


CO2 Saturation (v/v)

- Model plume extent was 1,000 ft radius in original model
- New model now shows plume extent nearly 1,700 ft
- Due to higher permeability in upper Paluxy sandstones
- Necessitates updated Area of Review
- MVA plan appears to be adequate
- Next step incorporate permeability variation within each sandstone – how does that affect the plume behavior?

Advanced Resources International, Inc.

Making Major Investments in CO_2 Monitoring



Risk Management Framework: Integrated CCS Project

CONSEQUENCE SEVERITY		CONSEQUENCE				LIKELIHOOD/FREQUENCY				
						A	B	C	D	E
						Remote:	Unlikely:	Possible:	Probable:	Frequent:
		Environment	Cost	Reputation	Schedule to start-up of operations	Very unlikely to occur during life-time of project	Unlikely to occur during lifetime of project	50-50 chance of occuring during lifetime of project	Likely to occur at least once during lifetime of project	Expected to occur several times during lifetime of project
	Very High	Persistent severe environmental damage. Extensive remediation required. Environment restored > 5 years.	More than $10 million	National or International media attention. Regulators shut down operations.	More than 12 months	M	M	H	H	H
	High	Severe environmental damage. Remediation measures required. Environment restored < 5 years	$1 to $10 million	Regional media attention. Regulatory or legal action taken	6-12 months	L	M	M	H	H
	Medium	Limited environmental damage managed by Company response teams. Environment restored < 2 years	$100 to $1000 k	Local media attention. Regulatory or legal action likely	3-6 months	L	L	M	M	H
	Low	Minor environmental damage, but no lasting effect	$10 to $100 k	Public awareness may exist, but there is no public concern	1-3 months	L	L	L	M	M
	Very Low	Slight environmental damage contained within the premises	Less than $10 k	On-site communications	Less than 1 month	L	L	L	L	M

MANAGING RISK DNV

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Questions?

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