Southeast Regional Carbon Sequestration Partnership

Highlights and Recent Developments

SECARB

NETL

SOUTHERN STATES ENERGY BOARD

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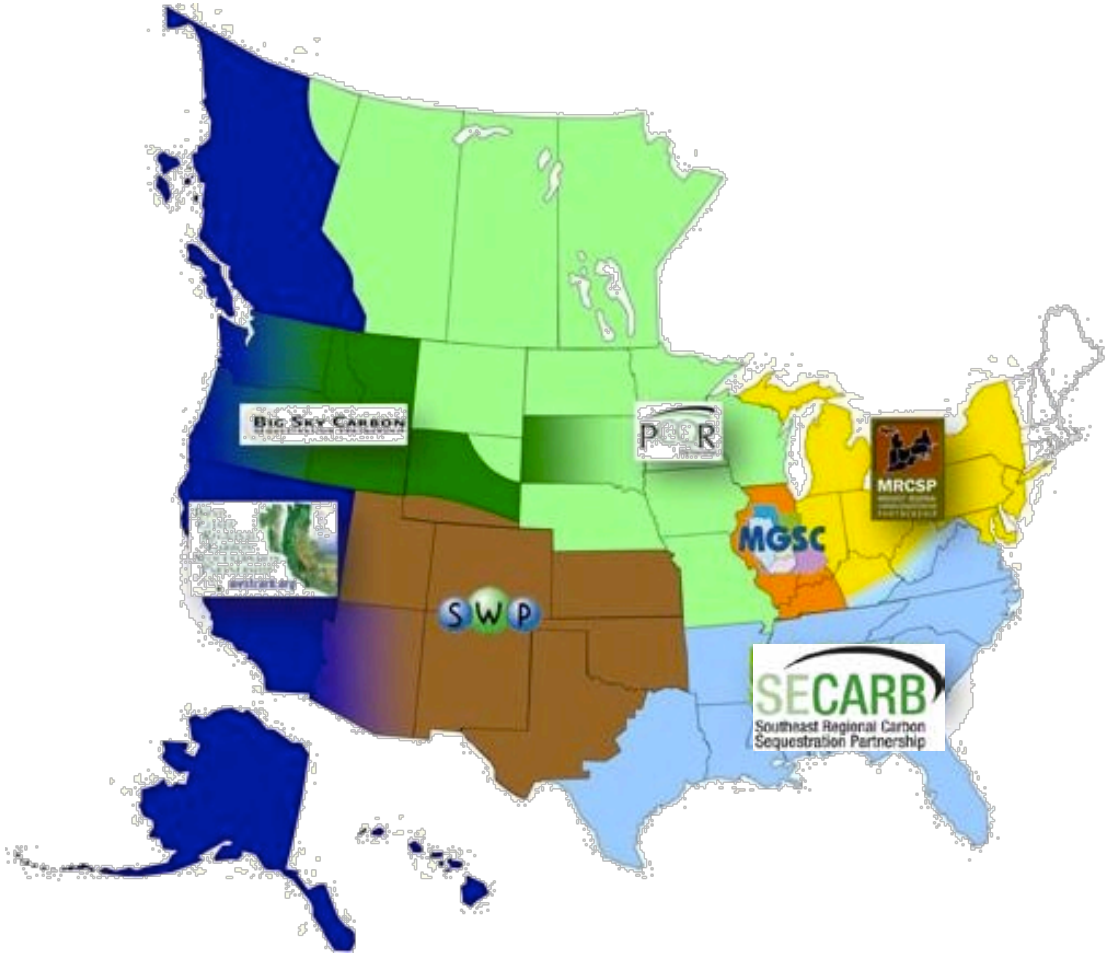
Presentation Outline

- SSEB Carbon Management
- SECARB Phase III Projects
- Cranfield Early Test
- Anthropogenic Test
- Future Plans

Regional Carbon Sequestration Partnerships (RCSP)

"Developing the Infrastructure for Wide Scale Deployment"

7 Partnerships, 400+ organizations, 43 States, 4 Canadian Provinces



Characterization Phase (2003-2005)

- Search of potential storage locations and CO_2 sources
- Found potential for 100's of years storage

Validation Phase (2005-2011)

- 18 injection tests in saline formations, depleted oil, unmineable coal seams, and basalt (not yet completed)

Development Phase (2008-2018+)

- 7 large scale injections (over 1 million tons each)
- Commercial scale understanding
- Regulatory, liability, ownership issues

SECARB Phase III Projects

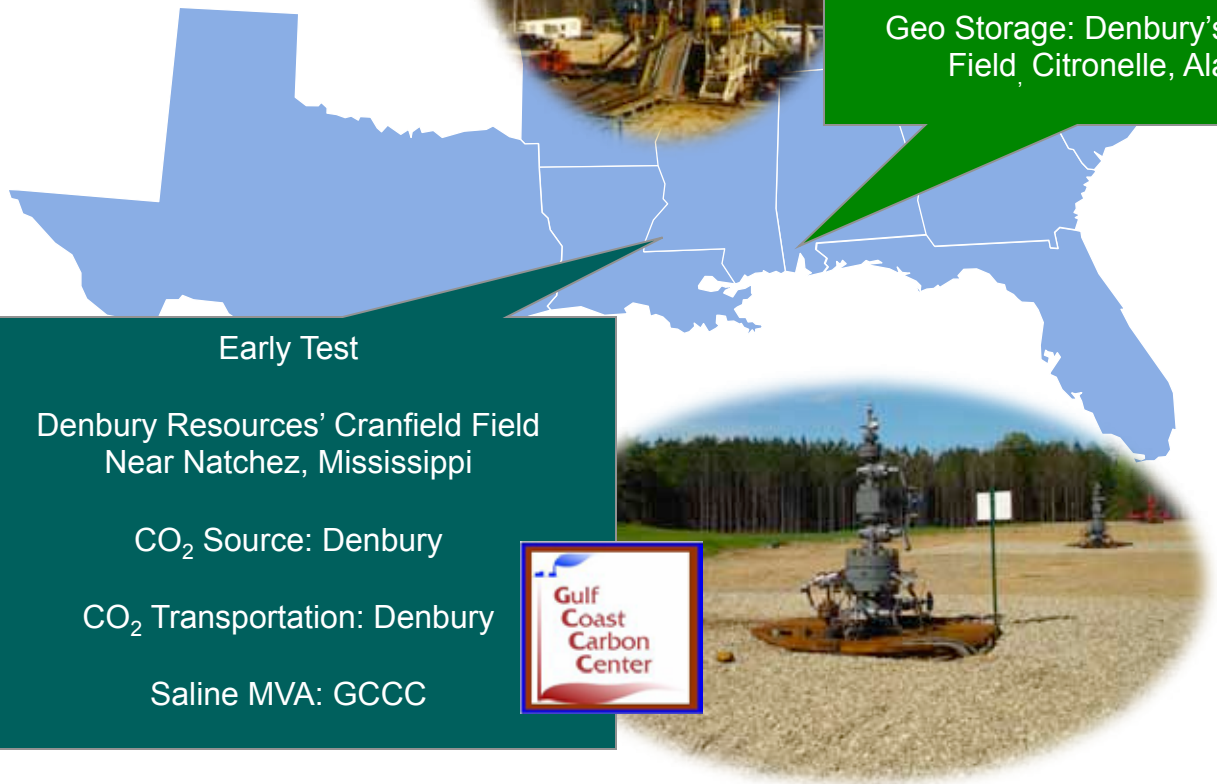
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Anthropogenic Test

Capture: Alabama Power 's Plant Barry, Bucks, Alabama

Transportation: Denbury

Geo Storage: Denbury's Citronelle Field, Citronelle, Alabama



Early Test

Denbury Resources' Cranfield Field Near Natchez, Mississippi

CO_2 Source: Denbury

CO_2 Transportation: Denbury

Saline MVA: GCCC

Gulf Coast Carbon Center

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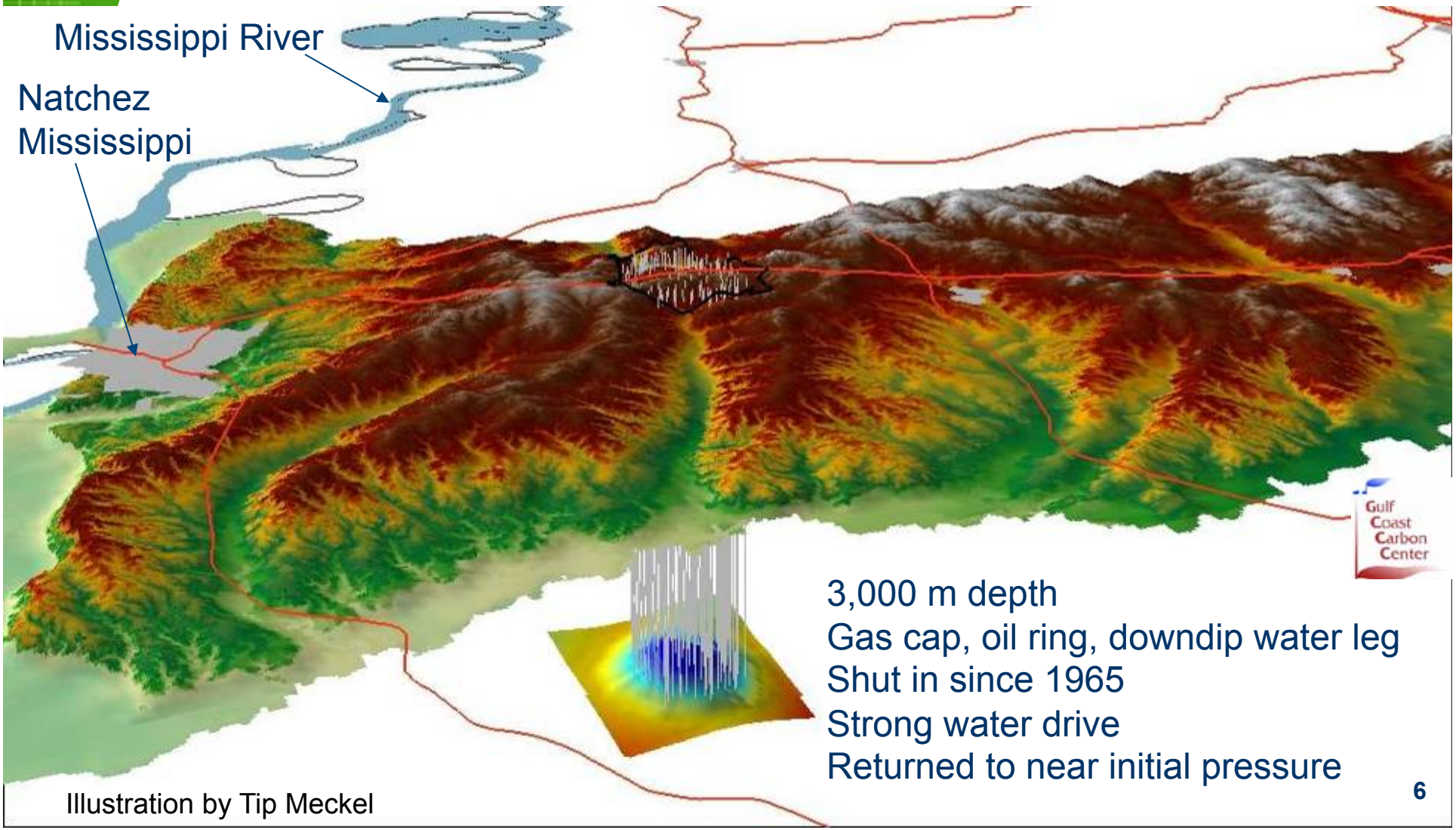
SECARB Early Test
Monitoring Large Volume Injection at Cranfield

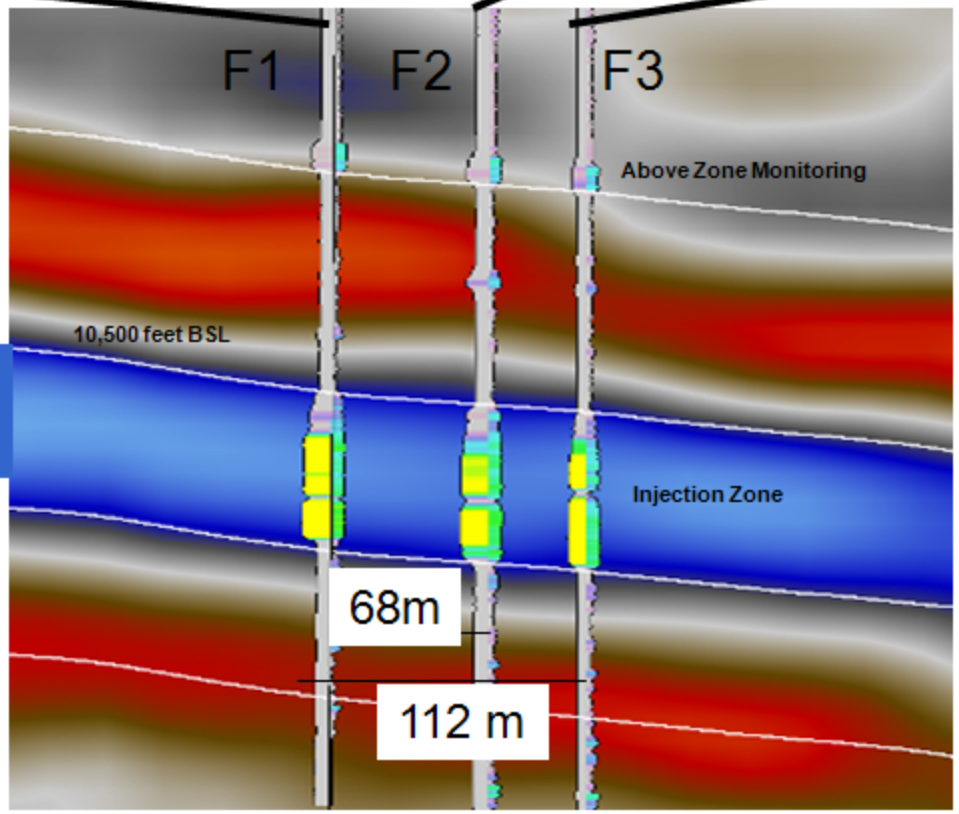


3,000 m depth
Gas cap, oil ring, downdip water leg
Shut in since 1965
Strong water drive
Returned to near initial pressure

Illustration by Tip Meckel

Cranfield Early Test Monitoring: Detailed Area of Study

Closely spaced well array to examine flow in complex reservoir



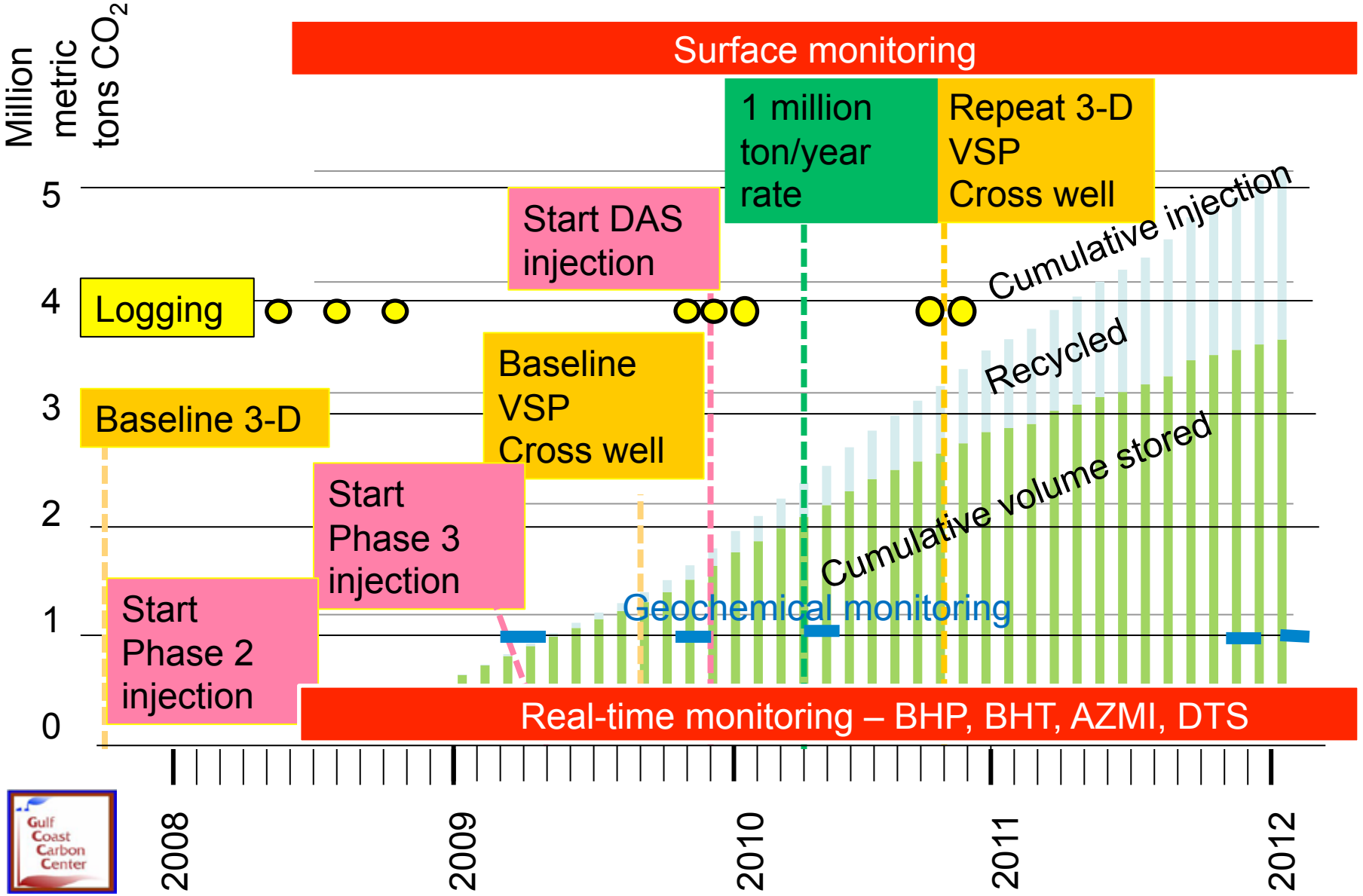
Confining system

Lower Tuscaloosa injection zone

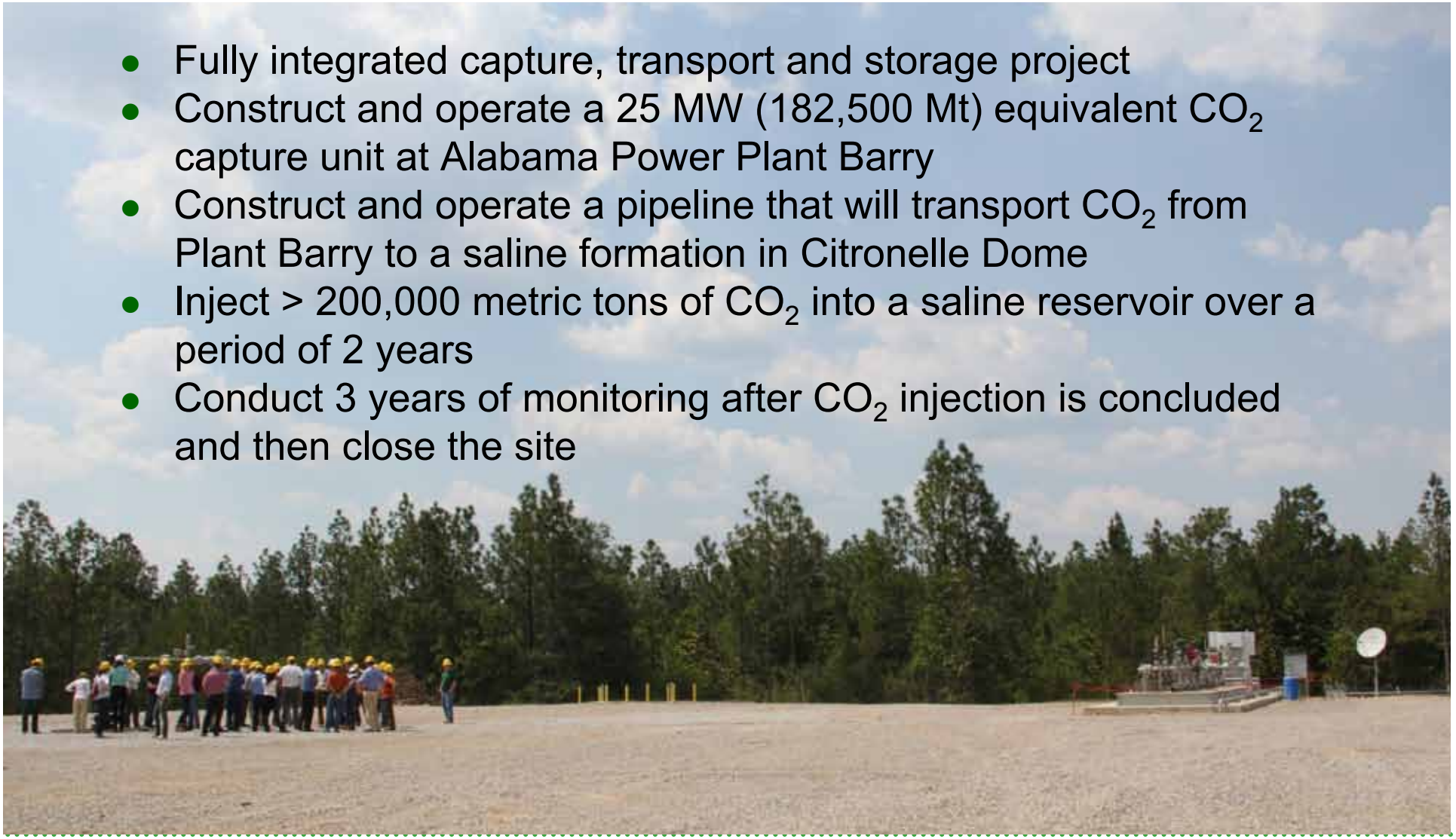
Gulf Coast Carbon Center

Early Test: Status (11/16/12)

Injected 6.3 million metric tons
Stored: 4.2 million metric tons
Difference is recycled CO_2



Anthropogenic Test: Project Overview



- Fully integrated capture, transport and storage project
- Construct and operate a 25 MW (182,500 Mt) equivalent CO_2 capture unit at Alabama Power Plant Barry
- Construct and operate a pipeline that will transport CO_2 from Plant Barry to a saline formation in Citronelle Dome
- Inject > 200,000 metric tons of CO_2 into a saline reservoir over a period of 2 years
- Conduct 3 years of monitoring after CO_2 injection is concluded and then close the site

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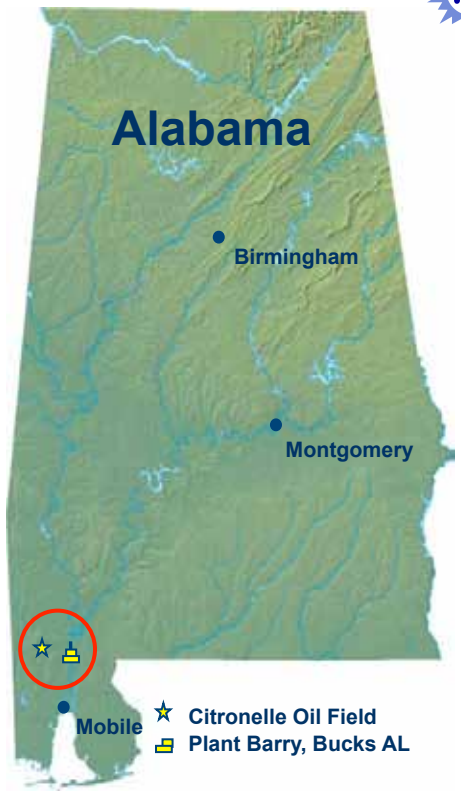
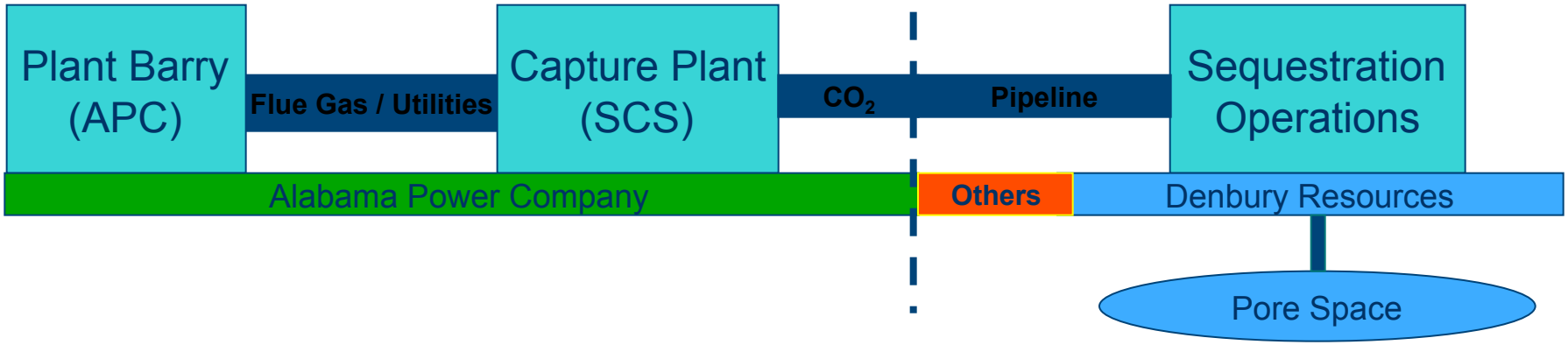


Capture Project

- Southern Company Services collaborating with MHI
- Location: APC's Plant Barry
- Research: SCS, MHI, EPRI
- CO_2 to pipeline: APC, SCS

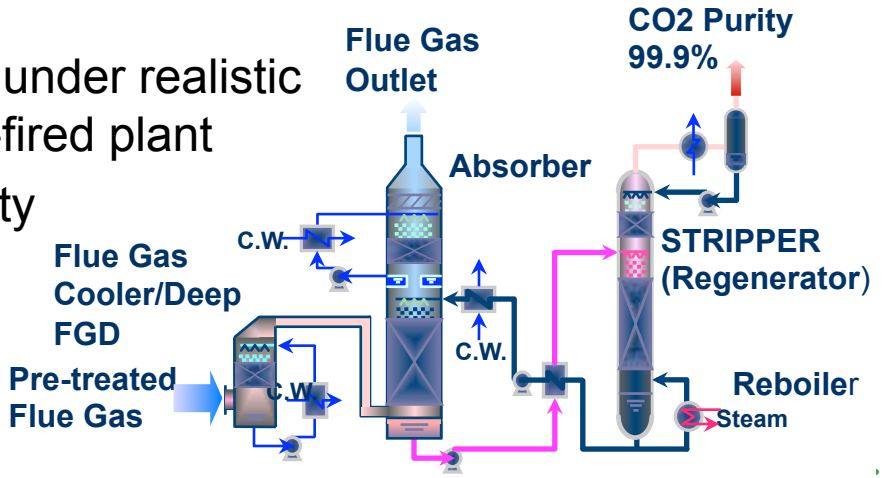
Sequestration Project

- Project: DOE's SECARB Phase III
- Prime contractor: SSEB
- Transport: Denbury's pipeline operations
- Injection: Denbury's Citronelle operations
- Research: ARI, EPRI, others



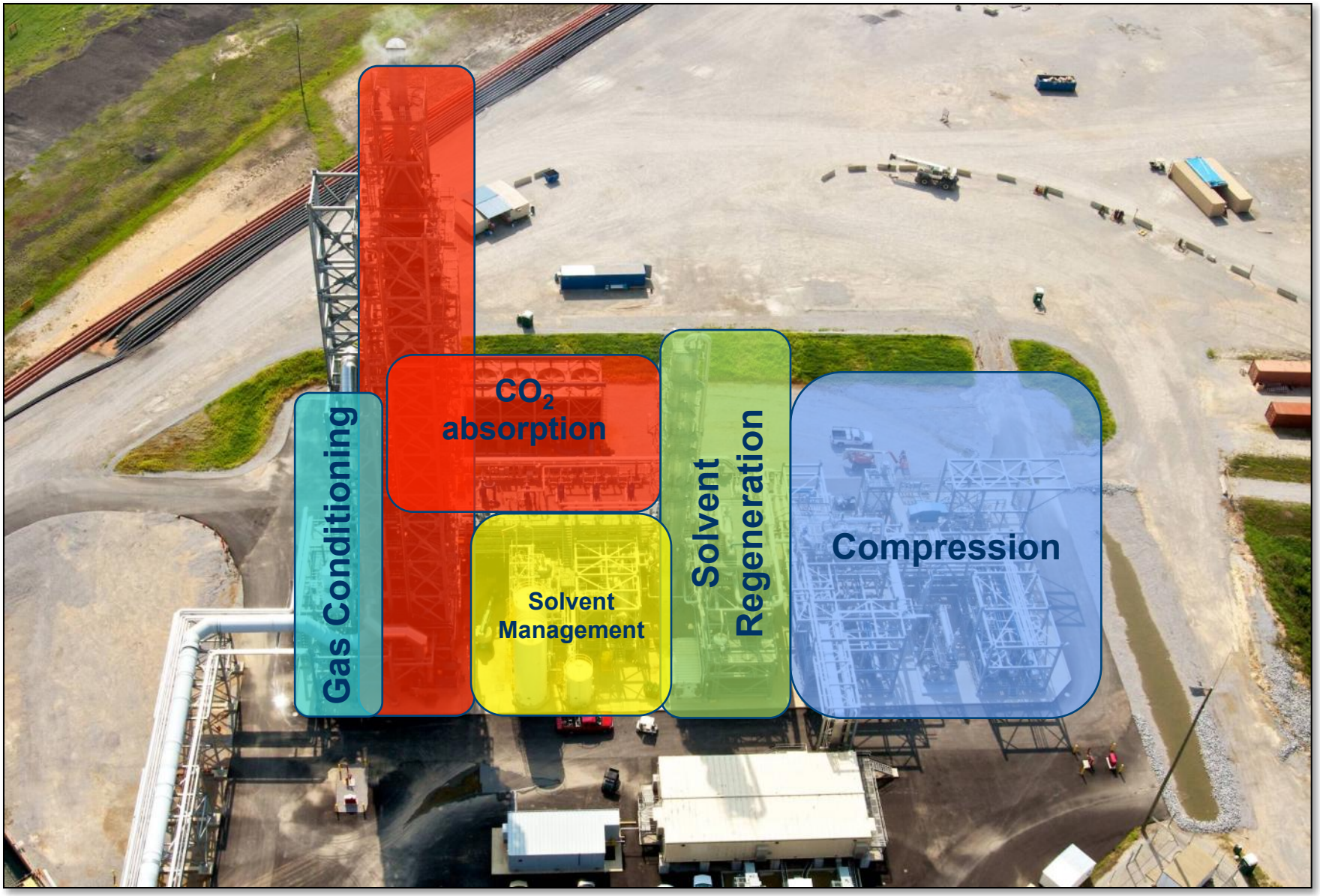
Capture Scope & Objectives

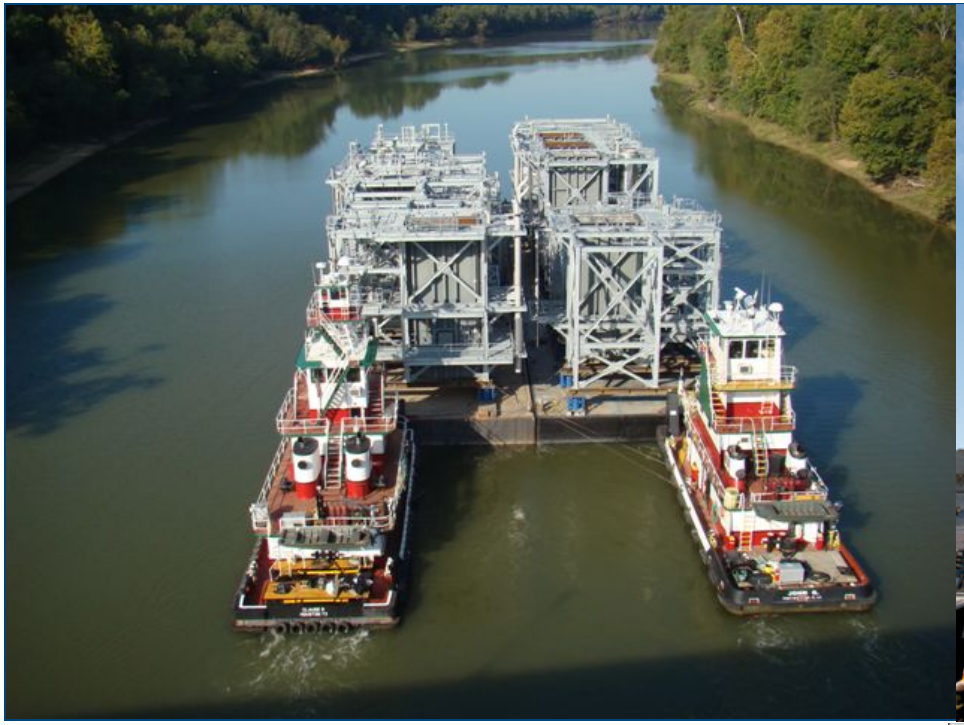
- **Project Scope:**
  - Demonstrate post-combustion capture of CO_2 from flue gas using MHI's advanced amine process
- **Project Philosophy:**
  - Fully representative of full scale design
  - Establish and demonstrate a contracting and execution strategy
  - Operation and maintenance in realistic conditions
  - Establish strategy for future commercial projects
- **Project Objectives:**
  - Demonstrate integrated CO_2 capture under realistic operating conditions typical of a coal-fired plant
  - Establish values for the energy penalty
  - Test reliability of solvent-based capture
  - Source CO_2 for injection demonstration



Simplified schematic post-combustion solvent process

Plant Barry Capture Unit: 25MW, 500 TPD





11/04/2010

Capture Plant Update

2010

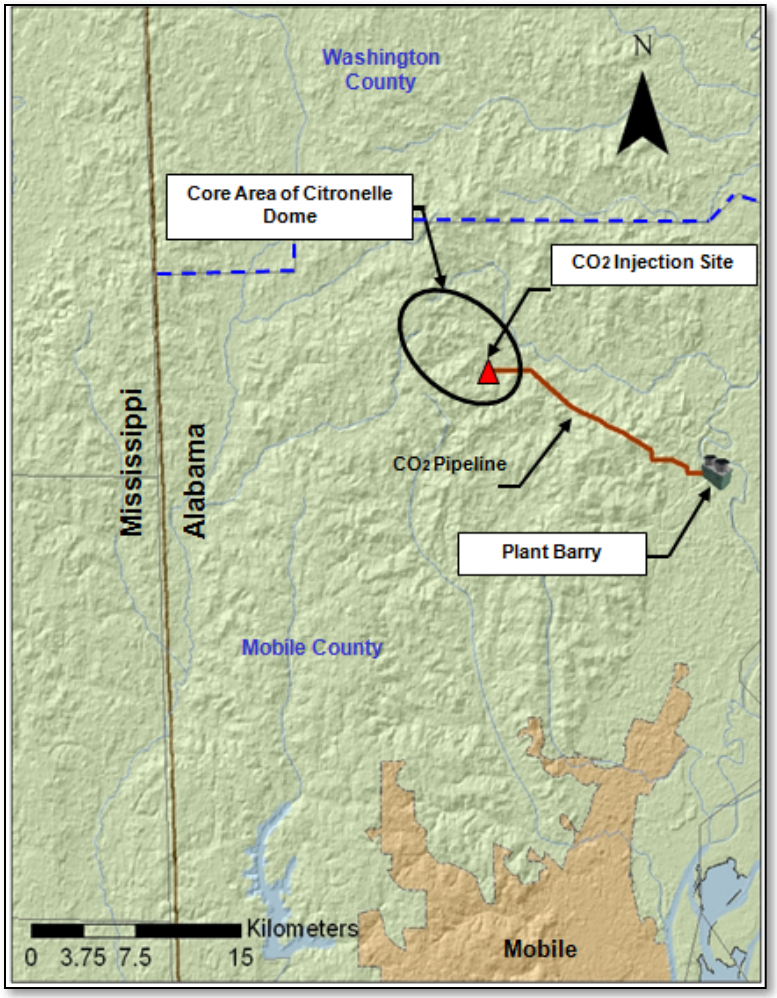
2012

June 2011: Capture plant & compressor started operations

November 2012: Over 120,000 tonnes CO_2 captured / 35,000 tonnes injected

CO_2 Pipeline Overview

- Approx. 12mi (19km) to the SE operators unit in Citronelle Field
- Pipe specifications
  - 4-in (10cm) pipe diameter
  - X42/52 carbon steel
  - Normal operating pressure of 1,500 psig (10.3 Mpa)
  - DOT 29 CFR 195 liquid pipeline; buried 5 feet with surface re-vegetation and erosion control
- Denbury pipeline purity requirement
  - >97% dry CO_2 at 115ºF (46ºC)
  - <0.5% inerts (including N_2& argon)
  - <30 lb water per 1MMSCF
  - <20 ppm H_2S



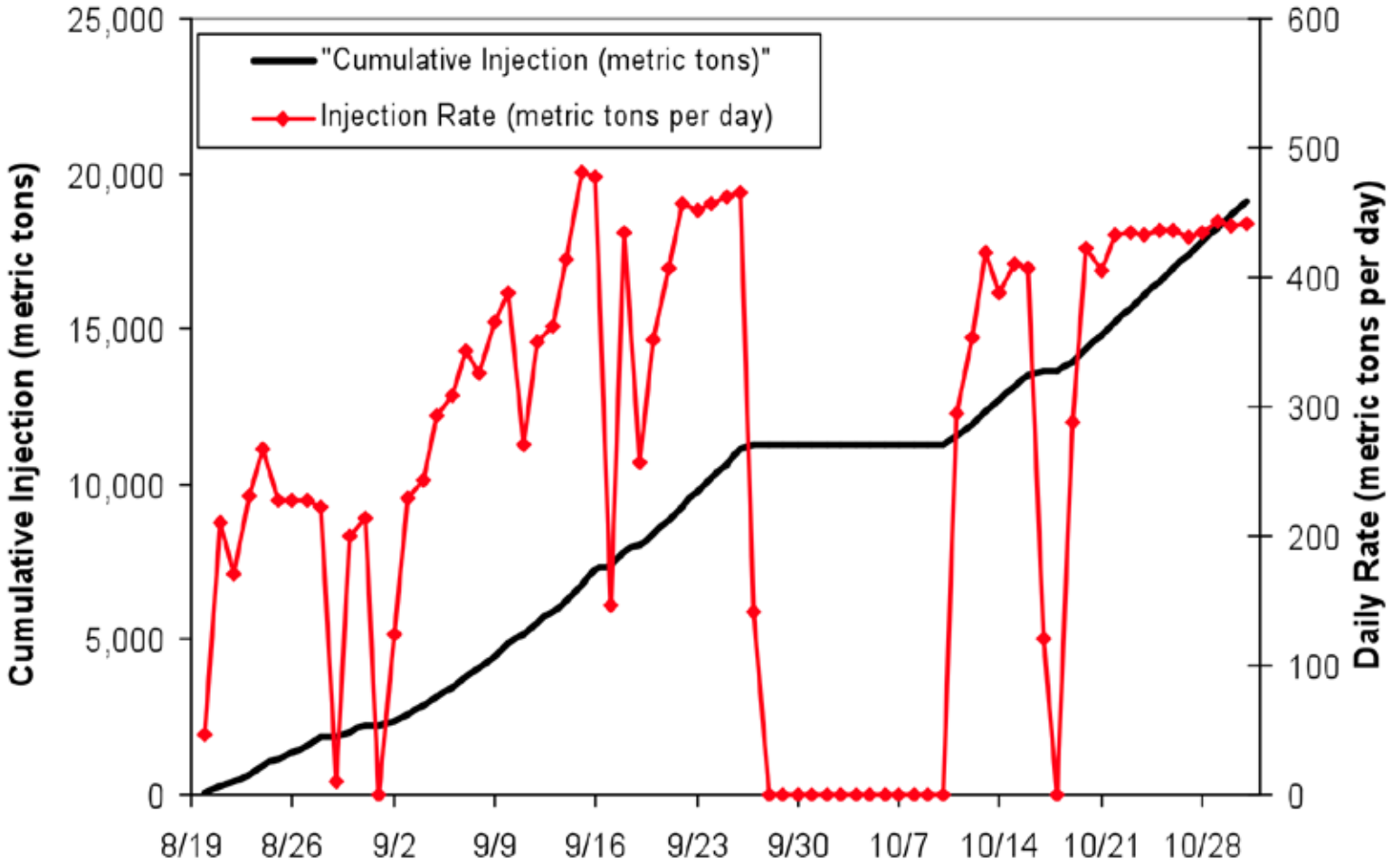
CO_2 Pipeline Overview

- Typical Pipeline/Injection Operations
  - 1,448 psi and 90^0F at the transfer station
  - Rate: 9.64 MMcfd (~480 tonnes/day) at 1,314 psi (wellhead) 63^0F.

- Typical CO_2 Purity

Component	%
N_2	0.011
O_2	0.010
CO_2	99.979

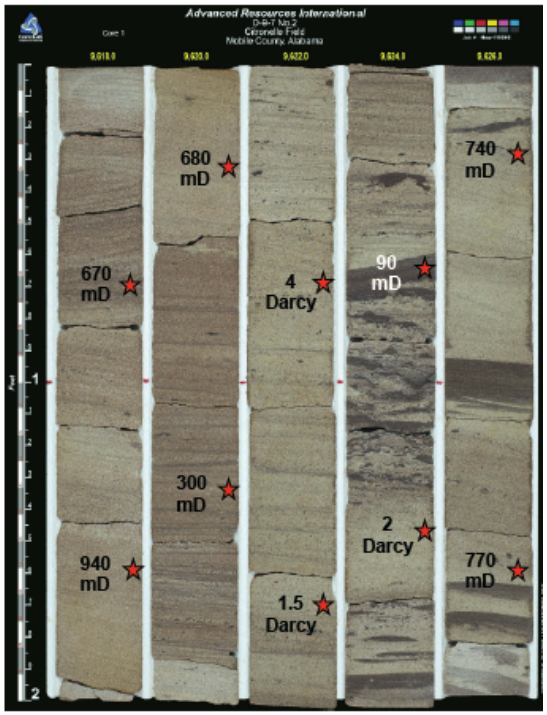
SECARB Anthropogenic Test: CO_2 Injection

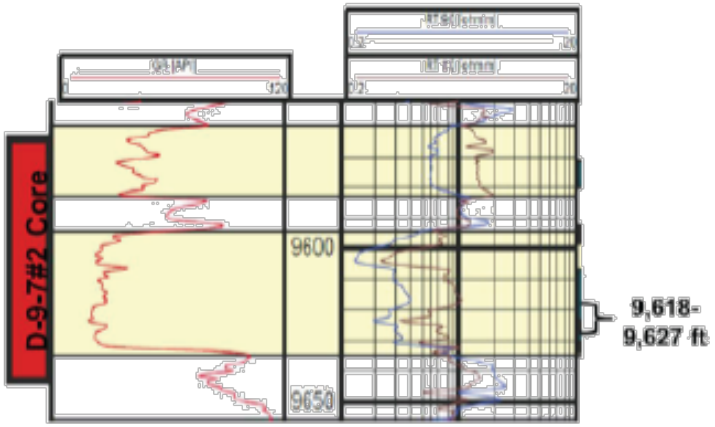


Citronelle Dome Stratigraphy

Stacked Storage Reservoirs with Multiple Seals and Four-Way Closure

System	Series	Stratigraphic Unit	Major Sub Units		Potential Reservoirs and Confining Zones
Tertiary	Plio-Pliocene		Citronelle Formation		Freshwater Aquifer
	Miocene	Undifferentiated			Freshwater Aquifer
	Oligocene		Chicasawhay Fm.		Base of USDW
		Vicksburg Group	Bucatunna Clay		Local Confining Unit
	Eocene	Jackson Group			Minor Saline Reservoir
		Claiborne Group	Talahatta Fm.		Saline Reservoir
		Wilcox Group	Hatchetigbee Sand Bashi Marl Salt Mountain LS		Saline Reservoir
	Paleocene				
		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 Basal Shale		Saline Reservoir 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' 'Middle' 'Lower'		Oil Reservoir Minor Saline Reservoir Oil Reservoir





SECARB Field Tests - Future Plans

- **Early Test at Cranfield Field**
  - Continue monitoring CO_2 injection and recycle
  - Upscale reservoir simulation 10-X
  - Second repeat seismic; consider repeat VSP and sonic logs
  - Evaluate above zone monitoring enhancements
- **Plant Barry and Citronelle Field**
  - Injection continues until January 2013 (Plant Barry shuts down)
  - Resume injection in spring 2013
  - Further automate / integrate capture, transport and injection operations
  - Evaluate capture enhancement options
  - Evaluate injection target options