

# SECARB

## Southeast Regional Carbon Sequestration Partnership (SECARB)

### Phase III Anthropogenic CO<sub>2</sub> Injection Field Test

#### Field Test Location and Amount/Sources of CO<sub>2</sub>

##### Anthropogenic Test

- Alabama Power's Plant Barry
- 100,000 to 150,000 tonnes of CO<sub>2</sub> per year
  - Coal-Fired Power Plant (Commercial/Anthropogenic Source)

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#### Field Test Partners

##### Primary Sponsors

U.S. Department of Energy  
National Energy Technology  
Laboratory  
Southern States Energy Board

##### Industrial Partners

(in alphabetical order)  
Advanced Resources International  
Alabama Power  
Denbury Resources, Inc.  
Electric Power Research Institute  
Geological Survey of Alabama  
Southern Company  
Southern Natural Gas

##### About SECARB

SECARB is one of seven Regional Carbon Sequestration Partnerships (RCSP) established by the U.S. Department of Energy (DOE) in 2003. The seven partnerships form a national network of more than 400 organizations covering 43 states and four Canadian provinces. The SECARB program spans 13 states in the southeastern United States and is funded by DOE and cost-sharing partners.

#### Summary of Field Test Site and Operations

Past work by Southeast Regional Carbon Sequestration Partnership's (SECARB) has identified that a series of thick, regionally extensive saline formations with high-quality seals exist within the Gulf Coastal Region. These saline formations have the potential to hold large volumes of carbon dioxide (CO<sub>2</sub>). One such formation, the Cretaceous-age Paluxy Formation sandstone, is the target for the SECARB Anthropogenic CO<sub>2</sub> storage test, **Figure 1**.

The Anthropogenic CO<sub>2</sub> storage field test is being performed in southwest Alabama near the town of Citronelle in northern Mobile County. The CO<sub>2</sub> source for the test is a newly constructed post-combustion CO<sub>2</sub> capture facility at Alabama Power's existing 2,657 MW Barry Electric Generating Plant (Plant Barry). A small amount of flue gas from Plant Barry (equivalent to the amount produced when generating 25 MW of electricity) will be diverted from the plant and captured using a process developed by Mitsubishi Heavy Industries to produce highly pure CO<sub>2</sub>. Plant Barry is a coal- and natural gas-fired electrical generation facility located in Bucks, Mobile County, Alabama, **Figure 2**. (Alabama Power is a subsidiary of Southern Company.)

The CO<sub>2</sub> storage site is located within the Citronelle Dome geologic structure. The Citronelle Dome, which provides secure four-way closure free of faults or fracture zones, is located approximately 15 kilometers west of Plant Barry. A pipeline was constructed in 2011 to link the CO<sub>2</sub> capture system with the Paluxy Formation, a major reservoir containing saline water (i.e. water that is too deep and salty to serve as a drinking water supply). The Paluxy occurs at a depth of 3,000 to 3,400 meters. The Paluxy is overlain by multiple geologic confining units that serve as vertical flow barriers and will prevent CO<sub>2</sub> from escaping from the storage reservoir, **Figure 1**.

Three new wells will be drilled during the test; a reservoir characterization well, an observation/backup injection well, and a dedicated CO<sub>2</sub> injection well. The characterization well, the first deep well drilled at Citronelle since the 1980's, was completed in January 2011 (**Figure 3**). Modern characterization data were collected on the injection zone, confining zones and the oil reservoir. The primary injection well was drilled in December 2011 and the backup injector was drilled in January 2012. In addition to the new wells, the project will utilize several existing idle oilfield wells surrounding the CO<sub>2</sub> injection site to monitor injection operations and to ensure public safety.

Beginning in 2012, between 100,000 and 150,000 metric tons per year of CO<sub>2</sub> captured from the pilot facility at Plant Barry will be transported to the storage site. CO<sub>2</sub> injection will continue for a period of two to three years.

During the injection period, multiple CO<sub>2</sub> monitoring technologies will be deployed to track the CO<sub>2</sub> plume, to measure the pressure front, to understand CO<sub>2</sub> trapping mechanisms of the Paluxy saline formation, and to monitor for potential leakage. Three years of post-injection monitoring are planned. Site closure is expected to occur in 2017. The wells will either be plugged and abandoned per state regulations or re-permitted for CO<sub>2</sub>-enhanced oil recovery operations in a deeper mineral formation.

System	Series	Stratigraphic Unit	Major Sub Units	Potential Reservoirs and Confining Zones	
Tertiary	Pliocene		Citronelle Formation	Freshwater Aquifer	
	Miocene	Undifferentiated		Freshwater Aquifer	
			Chicasawhay Fm. Bucatanua Clay	Base of USDW	
	Oligocene	Vicksburg Group		Local Confining Unit	
	Eocene	Jackson Group		Minor Saline Reservoir	
		Claiborne Group	Talahatta Fm.	Saline Reservoir	
		Wilcox Group	Hatchetigbee Sand	Saline Reservoir	
	Pleistocene		Bashi Marl Salt Mountain LS	Saline Reservoir	
		Midway Group	Porters Creek Clay	Confining Unit	
	Cretaceous	Upper	Selma Group		Confining Unit
Eutaw Formation				Minor Saline Reservoir	
Tuscaloosa Group			Upper		Minor Saline Reservoir
			Middle	Marine Shale	Confining Unit
			Lower	Pilot Sand Massive sand	Saline Reservoir
Cretaceous	Lower	Washita-Fredericksburg	Dantzier 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

Figure 1. Citronelle Dome Stratigraphy.

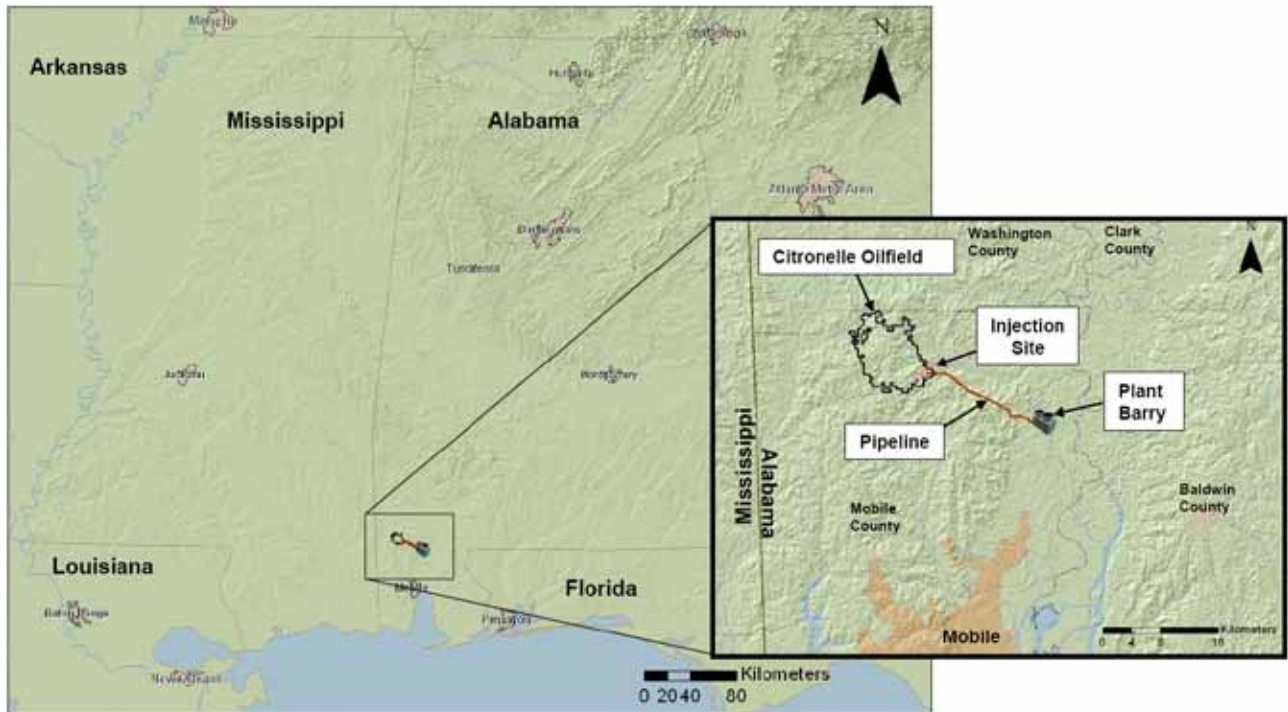


Figure 2. Geographic Location of the SECARB Phase III Anthropogenic Test.



**Figure 3. D-9-8#2, Characterization Well Drilling**

## **Research Objectives**

The purpose of the SECARB Phase III project is to test and demonstrate safe, secure CO<sub>2</sub> injection and storage in significant, regionally extensive saline reservoirs. Phase III will draw from and build on the Phase II sequestration “lessons learned” and will work to validate sequestration technologies of well design and integrity, monitoring protocols, injection operations as well as regulatory, permitting and outreach. The multi-partner collaborations developed during Phase I and II continued in Phase III.

In the Anthropogenic Test, the R&D objectives are to: 1) test the CO<sub>2</sub> flow, storage and CO<sub>2</sub> trapping mechanisms of the Paluxy Formation; 2) evaluate injection and storage capacity of a major saline reservoir in the Gulf Coast; 3) evaluate the integration of power plant CO<sub>2</sub> capture, transportation, injection and long-term geologic storage; 4) understand how the saline reservoir’s internal architecture (the interplay between the reservoir flow units, seals and baffles) can be effectively used to maximize available CO<sub>2</sub> storage capacity and minimize the areal extent of the CO<sub>2</sub> plume; 5) test commercially available, but not yet utilized, “off-the-shelf” and experimental CO<sub>2</sub> monitoring technologies; and 6) evaluate the effect of anthropogenic CO<sub>2</sub> captured from a coal-fired power plant on the geochemistry of a saline reservoir.

## Summary of Monitoring and Modeling, Verification and Accounting (MVA) Efforts

The MVA strategy at the Anthropogenic Test is designed to test commercially available “off-the-shelf” technologies in a manner not utilized before to better understand their performance and future application as listed in the table below.

Table 1. Measurement Technologies to be Deployed at the Anthropogenic Test.

Measurement Technique	Measurement Parameters	Application
Bottom-hole pressure	Pressure transducers deployed down hole near the injection interval	Key measurement for assessing the reservoir’s, injectivity, capacity and pressure field.
Cased-hole logging (pulsed neutron capture)	CO <sub>2</sub> and water saturations	CO <sub>2</sub> saturation buildup near new and existing wellbores to monitor for leakage along wellbores and to confirm models.
Time-lapse crosswell and vertical seismic imaging	Change from baseline sonic velocity and amplitude	Distribution of CO <sub>2</sub> plume vertically and horizontally to monitor for migration out of zone and to confirm reservoir models.
Above-zone pressure and fluid geochemical monitoring	Monitor for changes in pressure and deep saline water geochemistry (i.e., pH, metal concentrations)	Monitoring for CO <sub>2</sub> buildup above the primary confining unit.
Tracers introduced in the CO <sub>2</sub> stream	Measure tracer levels around area oilfield wells	Monitor for the presence of tracer buildup near new and existing wellbores which would suggest leakage of vertical CO <sub>2</sub> along the well annuli.
Drinking water aquifer monitoring	Monitor for changes in a wide suite of parameters (i.e. pH, alkalinity, cations and anions).	Monitoring of area freshwater aquifers for geochemical changes related to shallow CO <sub>2</sub> leakage.

### Accomplishments to Date

- A major geologic characterization effort was conducted on the injection reservoir and confining units using existing well and seismic data. Detailed maps of the Paluxy Reservoir sand units and multiple overlying confining units were created.
- The Environmental Impact Statement prepared by the project to fulfill the requirements of the National Environmental Protection Act resulted in a Finding of No Significant Impact.
- The project team has secured minerals and surface rights for the CO<sub>2</sub> storage test.
- The project’s first characterization/observation well was drilled in December 2010-January 2011. Data from this well will be used to refine the geologic model.
- The Underground Injection Control permit application was submitted to the Alabama Department of Environmental Management for the two injection wells in December 2010. Permits were issued in November 2011.
- In 2011, Denbury completed construction of a 12-mile pipeline to transport the CO<sub>2</sub> from Plant Barry to the injection well in the Citronelle oilfield.
- Injection well drilling began in December 2011, and the observation/backup injection well is being drilled in January 2012.
- Currently finalizing the Test Site risk assessment and evaluating mitigation strategies.

### Target Sink Storage Opportunities and Benefits to the Region

Gulf Coast Cretaceous-age formations are key components of a larger, regional group of similar formations, in terms of deposition and character, called the Gulf Coast Wedge. The wedge of sediments spans the entire SECARB region and includes the largest capacity saline sinks in the United States. CO<sub>2</sub> storage capacity estimates for the SECARB Gulf Coast Wedge range from 850-11,700 billion metric gigatons (Gt). In comparison, annual stationary point-source emissions of CO<sub>2</sub> for the region have been estimated to be 1.085 Gt. Using the range of reported CO<sub>2</sub> storage capacities, the saline formations in the Gulf Coast Wedge may have the capacity to accommodate these emissions for over 800 years.



## Project Cost and Key Dates

PHASE III PROJECT COST*			KEY PROJECT DATES	
	Dollars	Percent	ANTHROPOGENIC TEST	
DOE Share	\$76,981,260	69.10%	Drilling Operations Begin	12/2010 (characterization well) 12/2011 (injection wells)
Non-DOE Share	\$34,432,171	30.90%	Pre-Injection MVA Begins	8/2011
Total Value	\$111,413,431 (includes \$2,444,000 for Federal Laboratories)		Injection Operations Begin	3/2012
*Includes all Tasks for the Phase III Program			Injection Operations End	2014
			Post-injection MVA Ends	2017

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