

The SECARB Anthropogenic Test: The World's Largest Operating CCS System on a Coal Power Plant

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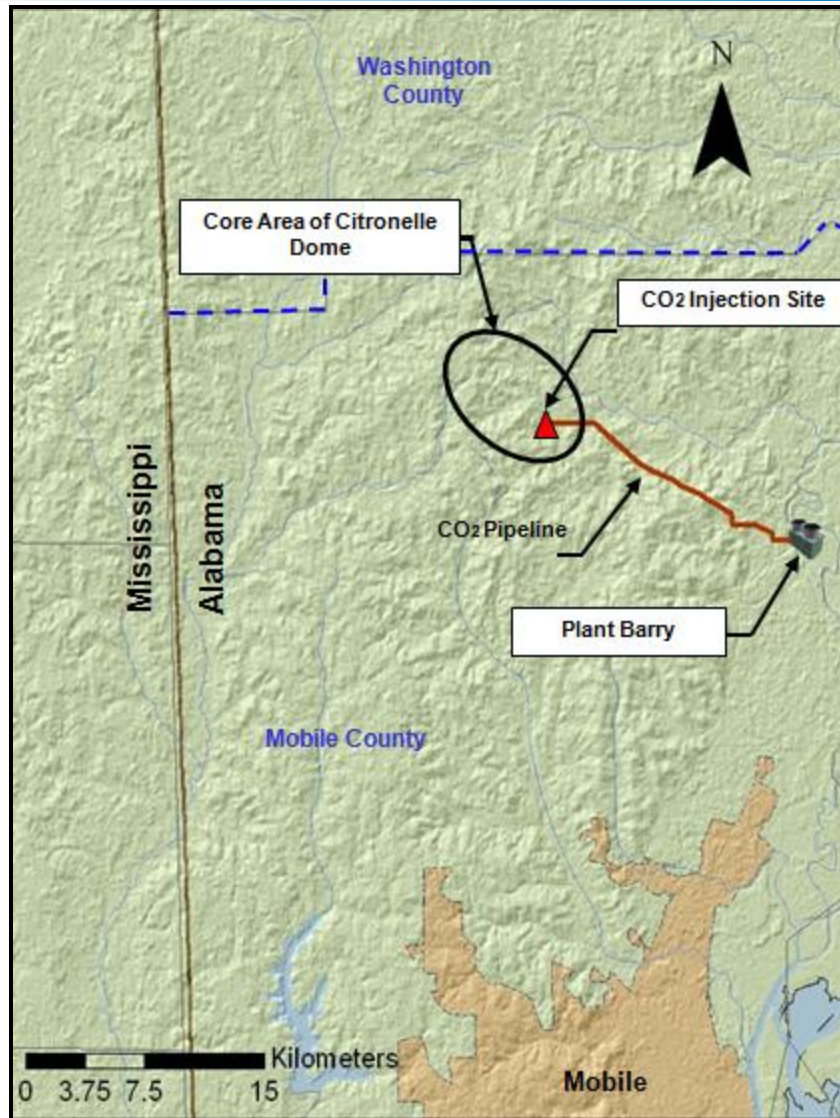
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Anthropogenic Test Schedule and Milestones

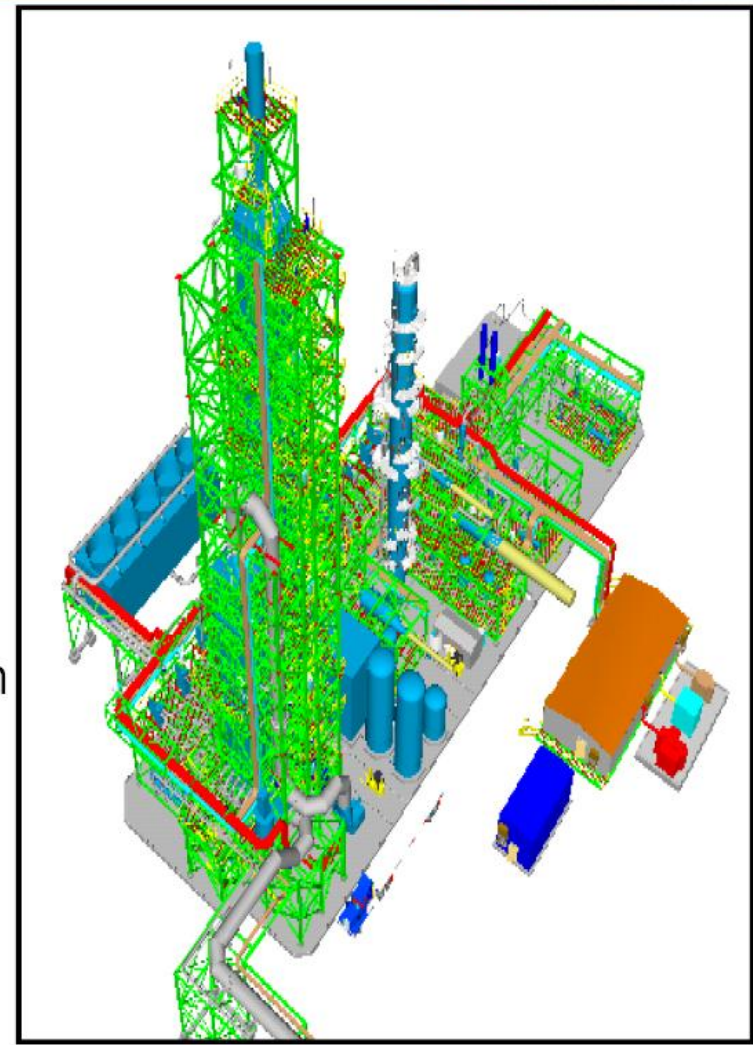


- The CO₂ capture unit at Alabama Power's (Southern Co.) Plant Barry became operational in 3Q 2011, over 100,000 tonnes captured
- 12 mile CO₂ pipeline from Plant Barry to the injection site completed in 4Q 2011
- A characterization well was drilled in 1Q 2011 to confirmed geology
- Injection wells were drilled in 4Q 2011
- Injection operations began in August, 2012, over 20,000 tonnes injected
- Up to 500 metric tonnes of CO₂ will be injected into a saline formation over 2 to 3 years
- 3 years of post-injection monitoring

25 MW Integrated CCS Demo – APC Plant Barry

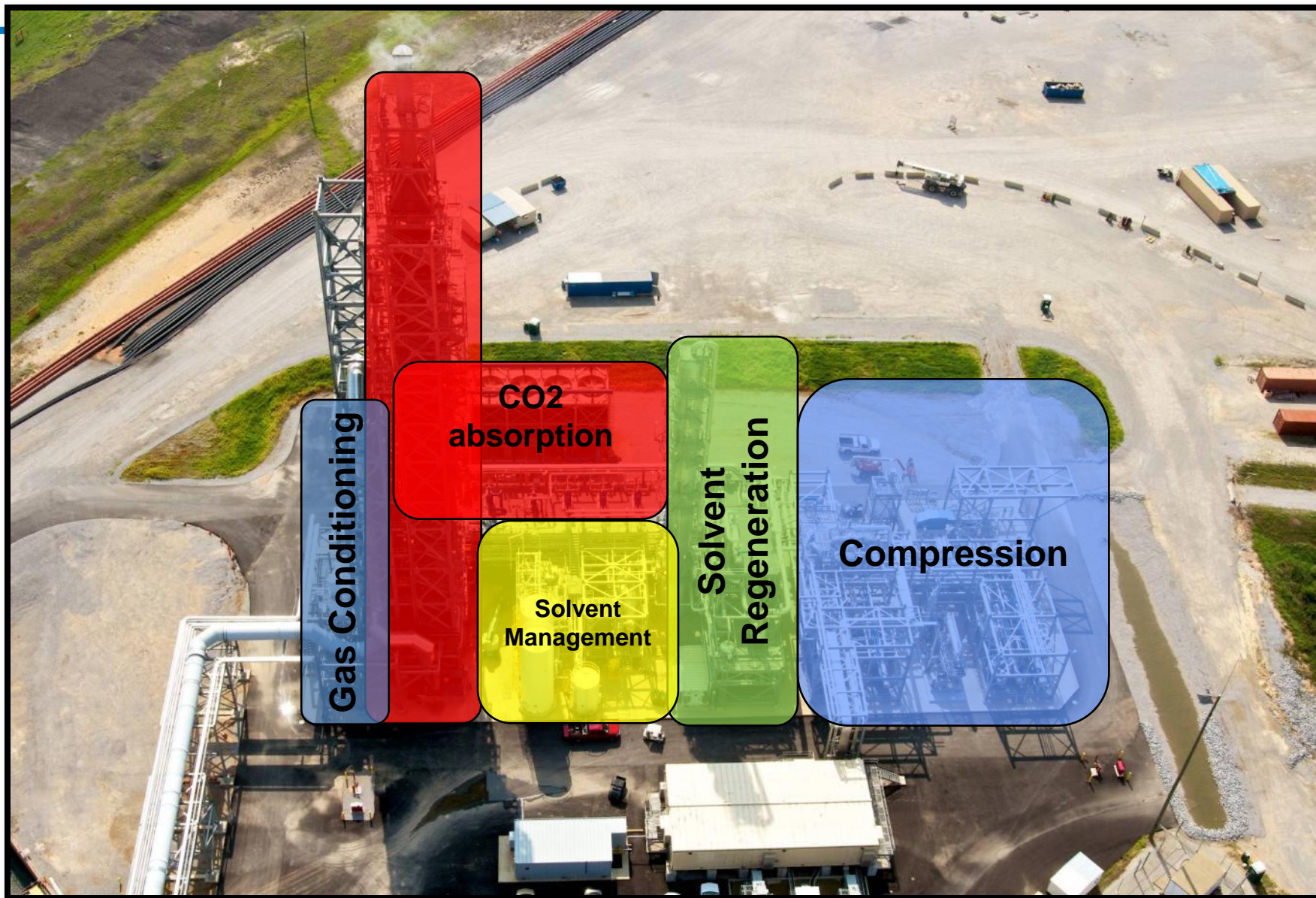
SOUTHERN
COMPANY

- CO₂ Capture and Compression
 - SCS/MHI collaboration with partners
 - KM-CDR capture technology (500 TPD)
- Transportation and Sequestration
 - DOE SECARB Phase III “Anthropogenic Test”
 - 150k tpy for up to 4 years into saline geology
 - ~15 mile CO₂ pipeline to Citronelle Field
- Objectives/Goals
 - Advance saline sequestration technology through large field test
 - Characterize operations to support full scale deployment
 - Continue outreach and education to insure seamless deployment





25MW, 500 TPD Demonstration



CO₂ Pipeline Right of Way

- Approx. 12 mi (19 km) to the SE Citronelle Unit in Citronelle Oil Field
- Right-of-Way
 - 1¼ mi (2 km) inside Plant Barry property
 - > 8 mi (13 km) along existing power corridor
 - 2 mi (3 km) undisturbed forested land
 - Permanent cleared width 20 ft (6 m)
 - Temporary construction width 40 ft (12 m)
- Right-of-Way habitat
 - 9 mi (14.5 km) of forested and commercial timber land
 - 3 mi (5 km) of emergent, shrub and forested wetlands
 - Endangered Gopher Tortoise habitat
 - 110 burrows in or adjacent to construction area



Courtesy of Denbury

CO₂ Pipeline Design

- Applicable regulatory standard: US Department of Transportation, 49 CFR Part 195 — Transportation of Hazardous Liquids by Pipeline
- 4-inch (10 cm) pipe diameter
- X52 carbon steel pipe, fusion bonded epoxy coated
- MOP – 2,220 psig (flange limitation)
- Normal operating pressure: 1,500 psig (10.3 MPa) maximum
- Buried average of 5 ft (1.5 m) with surface re-vegetation and erosion control



Handling pipe for horizontal directional drill

Courtesy of Denbury

Site Selection; Critical for Risk Minimization

System	Series	Stratigraphic Unit	Major Sub Units		Potential Reservoirs and Confining Zones
Tertiary	Plio-Pliocene		Citronelle Formation		Freshwater Aquifer
	Miocene	Undifferentiated			Freshwater Aquifer
	Oligocene	Vicksburg Group	Chickasawhay Fm. Bucatanua Clay		Base of USDW 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
	Lower	Washita-Fredericksburg	Dantzler sand Basal Shale		Saline Reservoir Primary Confining Unit
		Paluxy Formation	'Upper' 'Middle' 'Lower'		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

- Proven four-way closure at Citronelle Dome
- Injection site located within Citronelle oilfield where existing well logs are available
- Deep injection interval (9,400 ft)
- Numerous confining units
- Base of USDWs ~1,400 ft
- Existing wells cemented through primary confining unit
- No evidence of faulting or fracturing, based on oilfield experience, new geologic mapping and reinterpretation of existing 2D seismic lines.

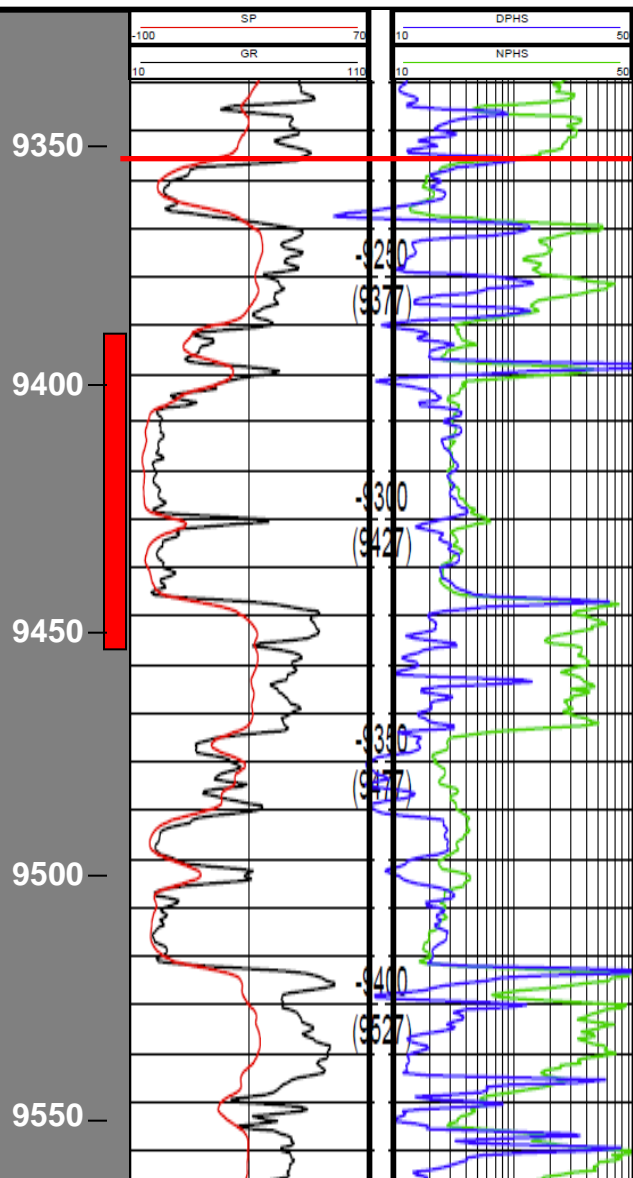
Expect the Unexpected: Turtle Soup!

U.S. Fish and Wildlife permit and NEPA compliance mandate the protection of threatened and endangered species

- Potential impacts to an threatened species and its habitat (Gopher Tortoise)
- Over 100 tortoise burrows encountered long pipeline easement
- Directional drilling under tortoise burrows/colonies less expensive than temporary relocation
- Burrows identified at or near most well sites
- Avoid drilling/monitoring activities in proximity to burrows



The Paluxy Formation is a Good Injection Target



Porosity Range: 6-18%
Permeability Range: 1 – 50 md

Porosity Average: 13 %
Permeability Average: 8 md

Porosity Range: 6-23%
Permeability Range: 1 – 3,800 md

Porosity Average: 18%
Permeability Average: 440 md

Porosity Range: 8-22%
Permeability Range: 1 – 1,900 md

Porosity Average: 18%
Permeability Average: 500 md

Medium to coarse grained sandstones of the upper Paluxy appear to represent excellent CO₂ injection targets

Permitting: This Stuff Takes a While

A Class V Experimental Well permit application submitted in December 2010

- Short duration of injection (3 years) and modest volumes of CO₂
- CO₂ Injection Under “real world” operating conditions
- Demonstration of experimental monitoring tools and methods

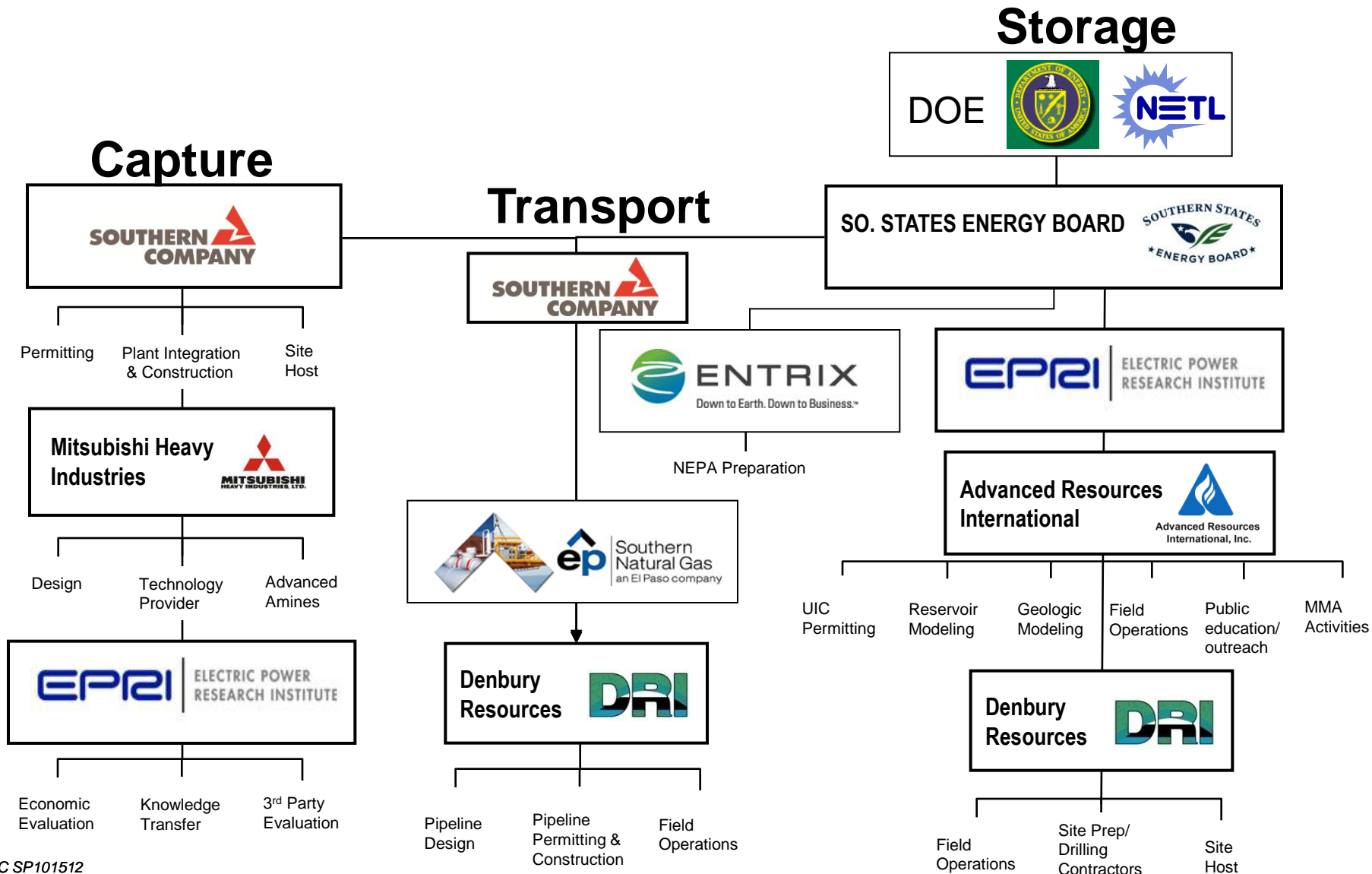
Most Class VI (CO₂ sequestration well) standards were applied

- Injection Area of Review (AOR) determined by modeling and monitoring results; updated annually
- Extensive deep, shallow and surface CO₂ monitoring
- Injection stream monitoring
- Periodically updated Corrective Action Plan
- Site closure based on USDW non-endangerment demonstration (5-yr renewal)
- Pressurized annulus throughout injection (+/- 200 psig)

Class V Experimental injection permit was awarded in November 2011, eleven months after initial draft application

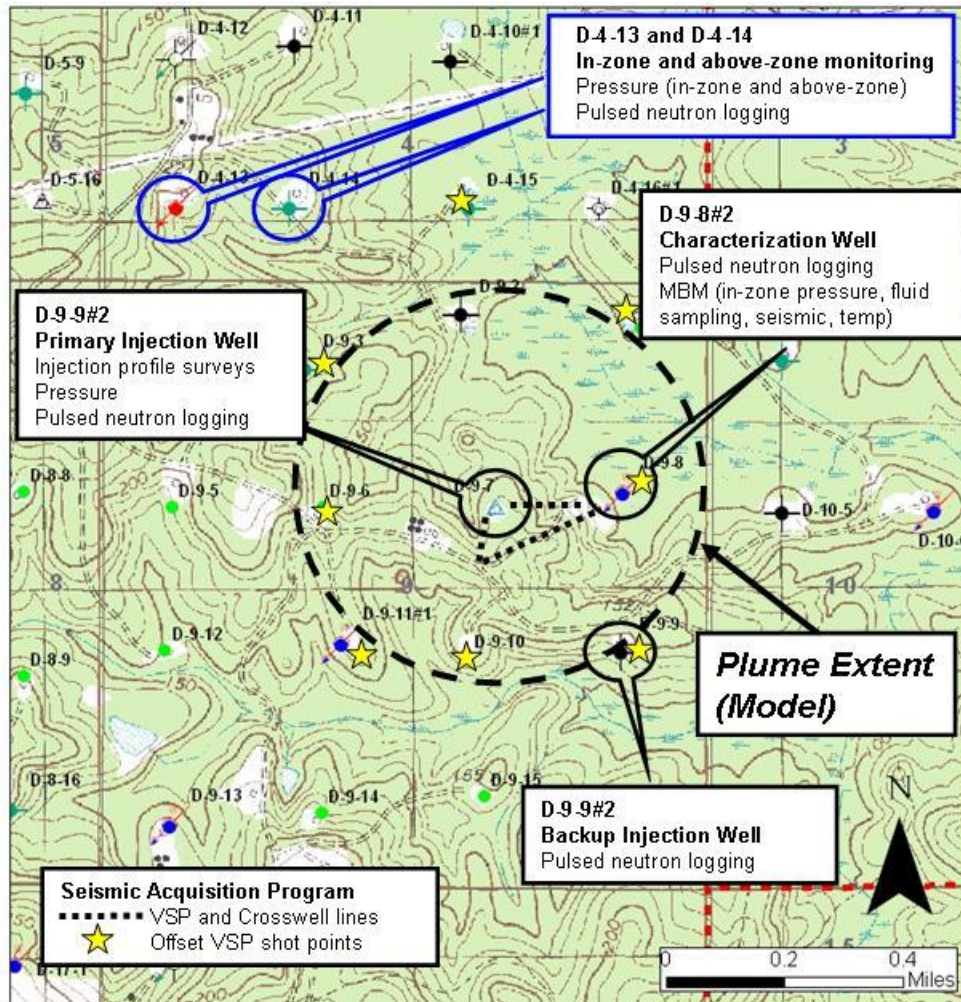
Permission to operate request submitted in April 2012; awarded in August 2012

Integration – Communication is Key!



Citronelle CO₂ Monitoring Plan

CO₂ Injection and Storage Site



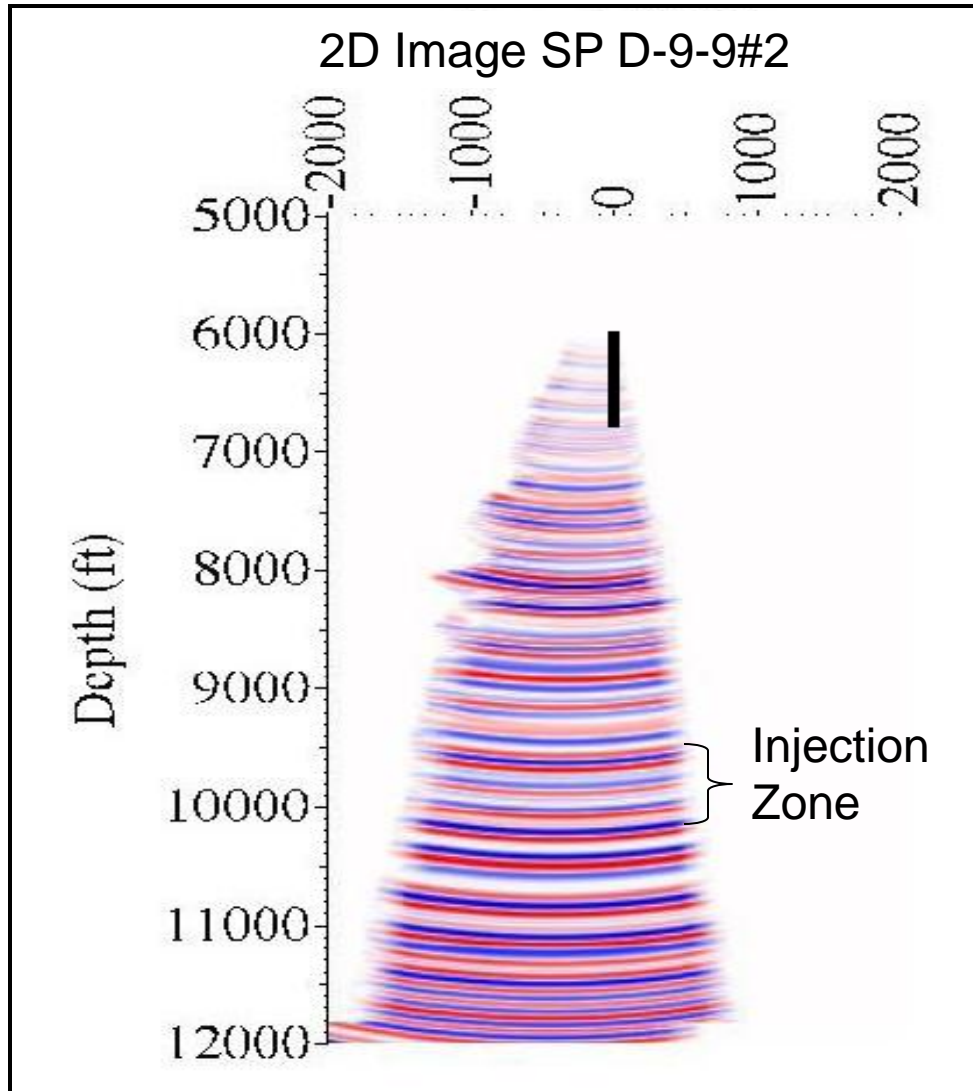
CO₂ Monitoring Design

The anthropogenic test will use five deep wells to track the CO₂ plume plus four shallow water monitoring wells:

- Near-surface and deep reservoir fluid sampling.
- In-zone and above-zone pressure and temperature monitoring.
- Cased-hole neutron logging.
- Crosswell seismic and VSP.
- Surface soil flux and tracer surveys
- Experimental Modular Borehole Monitoring System

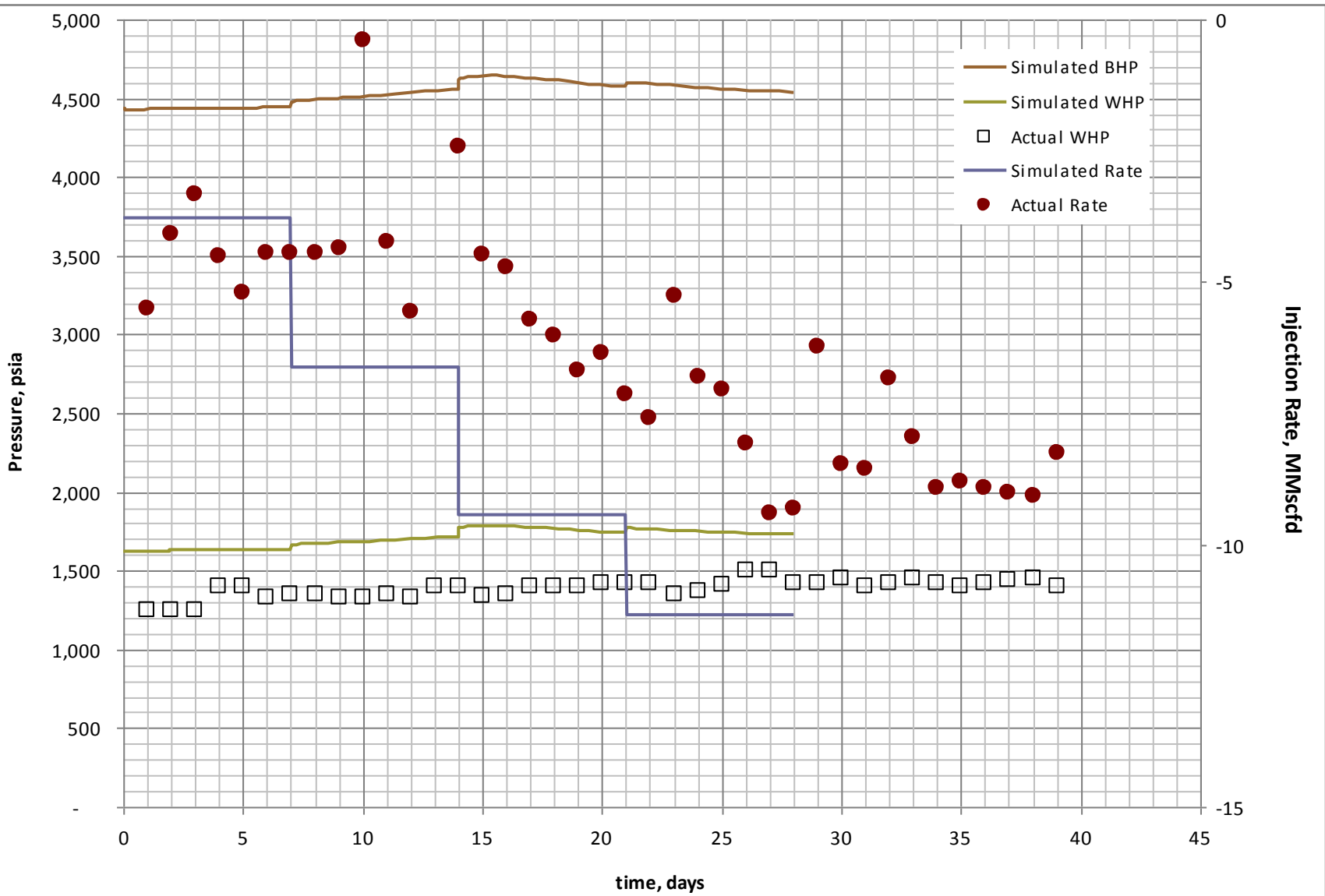
Results will be used to periodically update the reservoir model.

MVA Early Result: MBM Geophones Allow for Frequent VSPPs

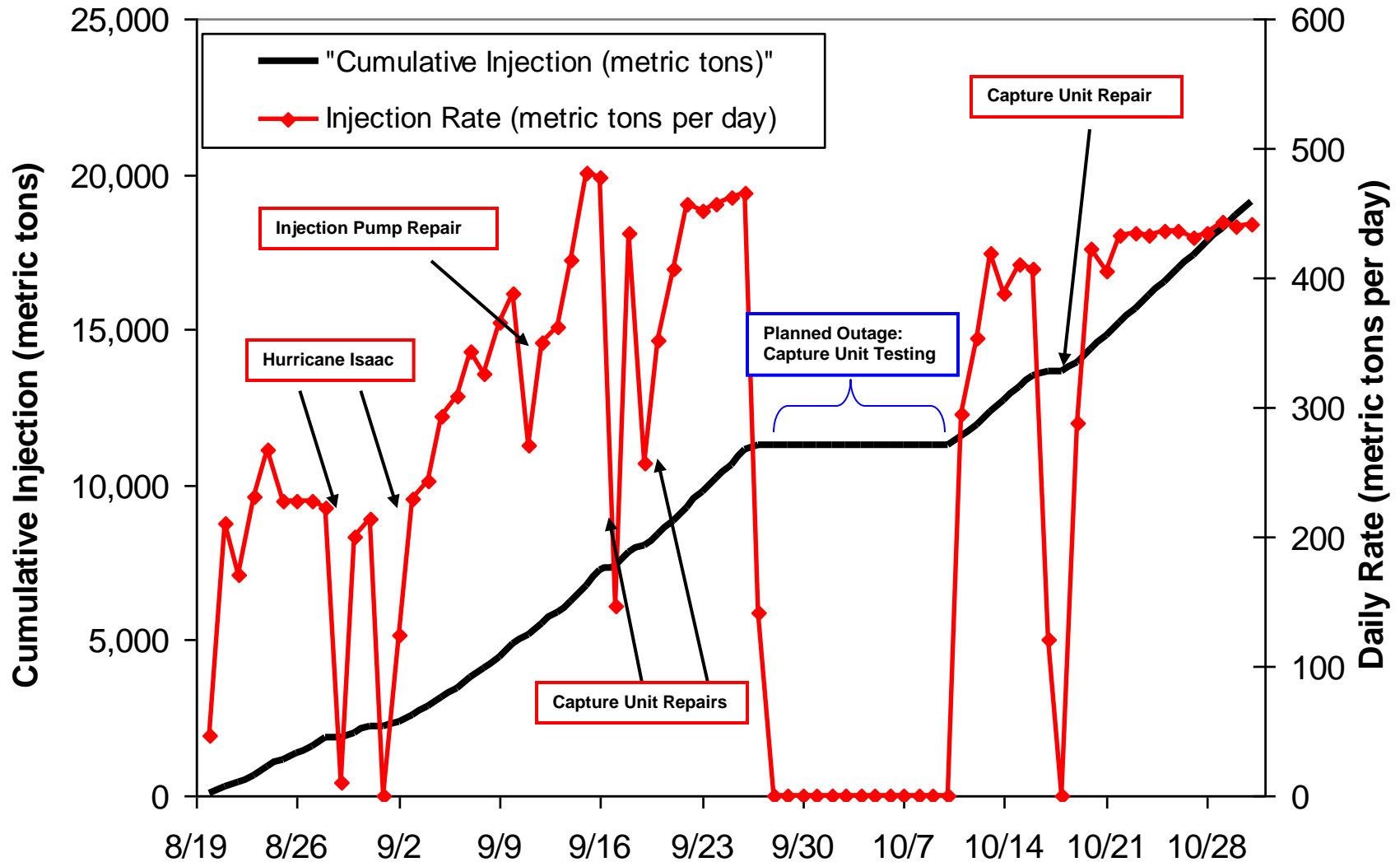


- MBM completion includes 18 semi-permanent geophones
- Plan is to acquire VSP utilizing MBM receivers and offset well pad source locations ~ twice per year
- Baseline images acquired at seven locations in April 2012
- Reduced lateral image area and vertical resolution compared to full VSP, but still functions as a qualitative predictor of CO₂ arrival

Injection Operations: Pressures are Lower Than We Predicted



Injection Operations: A Few Unplanned Outages So Far



“Path Forward” Accomplishments

- Design, construction, and operation of the world’s largest carbon capture unit on a pulverized coal-fired power plant with over 100,000 metric tons of CO₂ captured to date and with 20,000 metric tons injected into a saline reservoir.
- Designed, permitted, constructed, commissioned, and currently monitoring a 12 mile CO₂ pipeline linked to a coal-fired power plant with slip stream carbon capture.
- Unique UIC permit received for injection of CO₂ for geologic sequestration.
- MVA baseline monitoring including significant experimental/innovative technologies such as the modular borehole monitoring tool.

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