# Carbon Storage and Oil and Natural Gas Technologies Review Meeting

Richard Esposito, Southern Company Services
Dave Riestenberg, Advanced Resources International

Establishing an Early $CO^2$ Storage Complex in Kemper County, Mississippi: Project $ECO^2S$

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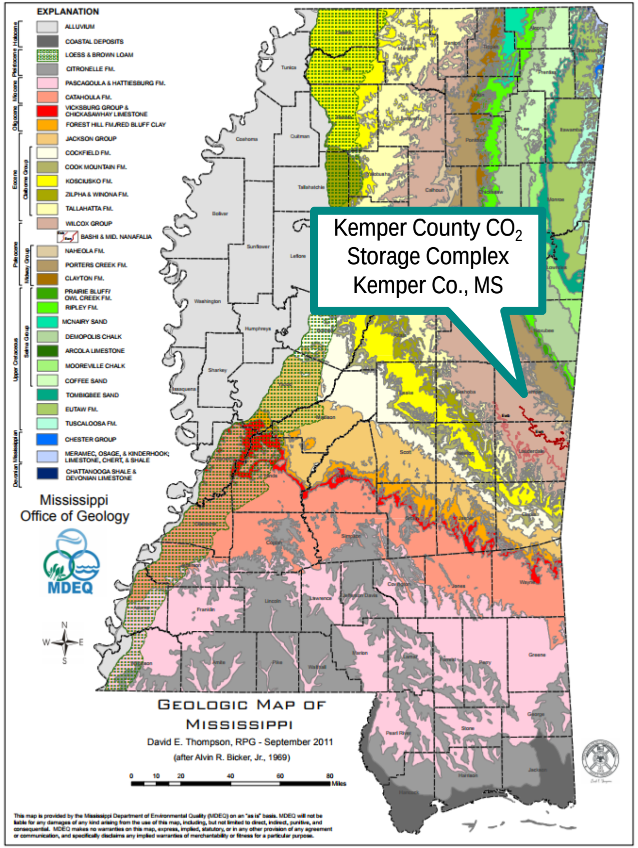
# Presentation Outline




I. Project $ECO_2S$ Introduction

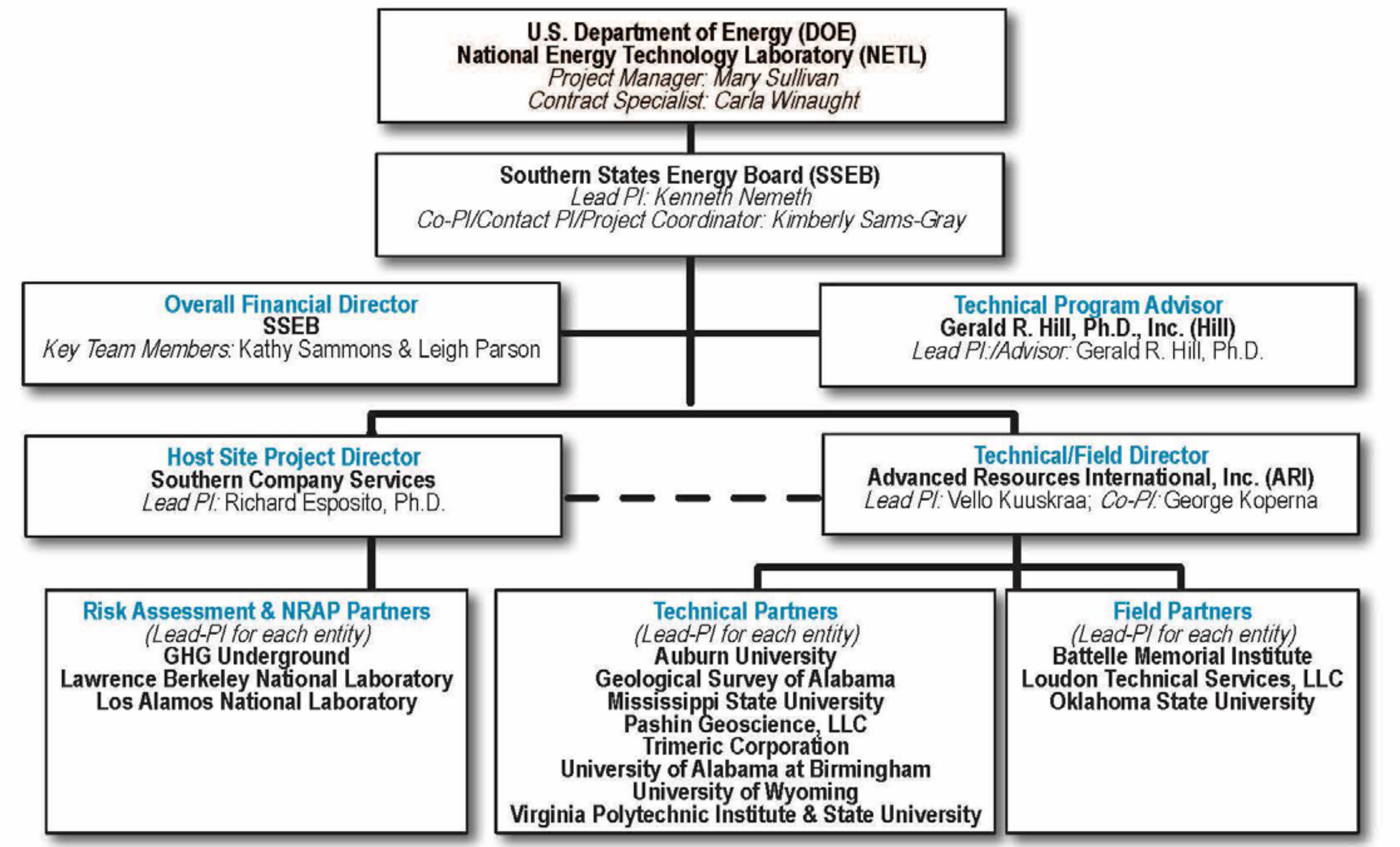
II. Geologic Characterization Plan

III. Results to Date

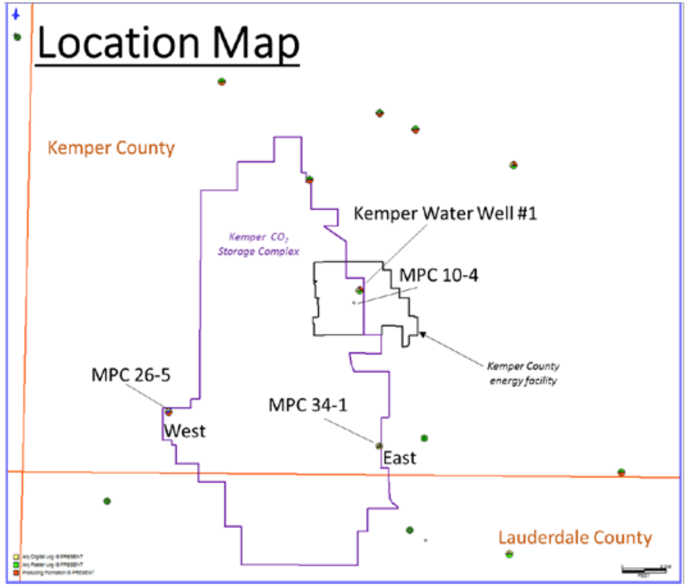
IV. Preliminary Storage Capacity

V. Conclusions

# Project $ECO_2S$ Organization Chart



# Project $ECO_2S$ Introduction




The project team has established an area of interest exceeding 30,000 acres in Kemper County, Mississippi.

Project $ECO_2S$, a DOE-supported CarbonSAFE program, will pursue key advances in $CO_2$ storage knowledge and technology, including: **optimizing $CO_2$ storage efficiency**, **modeling the fate of injected $CO_2$**, and **establishing residual $CO_2$ saturations**. In addition, Project $ECO_2S$ will involve "real-life" experiences, issues, and challenges of **scaling-up from its regional, pre-feasibility assessment of $CO_2$ storage** to **establish a site-specific, commercial-scale $CO_2$ storage facility**, including **capturing the "lessons learned"** in making this transition.

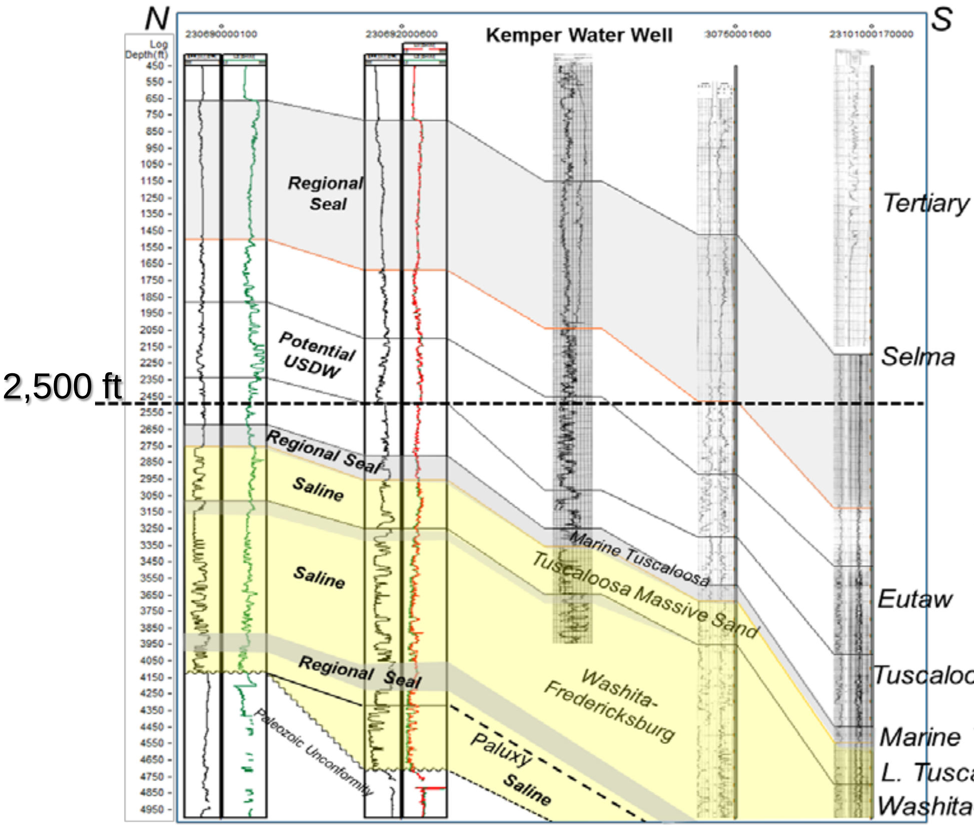
# Kemper County Storage Stratigraphy

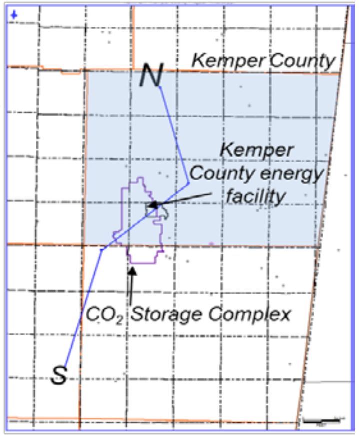
| | | | | |
|---|---|---|---|---|
| Tertiary | Eocene | Lower Wilcox Group | Nanafolia Fm. | Lignite/USDW |
| | Paleocene | Midway Group | Naheola Fm | Potential USDW |
| | | | Porter's Creek Clay | Regional Seal |
| Cretaceous | Upper | Selma Group | Predominately Chalk | Regional Seal |
| | | Eutaw Fm. | | Potential USDW |
| | | Tuscaloosa Group | Upper | Potential USDW |
| | | | Marine Shale | Regional Seal |
| | | | Lower Tusc. Massive Sand ★ | Potential Saline |
| | Lower | Washita- Fredericksburg ★ | | Saline |
| | | Paluxy Fm. ★ | | Saline |
| *Paleozoic Unconformity Ouachita Facies* | | | | |

- Three Cretaceous storage clastic units with high porosity:
  - Lower Tuscaloosa Group (massive sand)
  - Washita-Fredericksburg interval
  - Paluxy Formation
- Three prominent caprocks (reservoir seals):
  - Tuscaloosa marine shale
  - Shale interval at top of the Washita-Fredericksburg
  - Shale interval at base of Washita-Fredericksburg interval
- Shallow seals also in the Selma and Midway Groups

Source: Pashin, J.C., D.J. Hills, D. C. Kopaska-Merkel, M.R. McIntyre, Geological Evaluation of the Potential for $CO_2$ Sequestration in Kemper County, Mississippi, Final Report, prepared for Southern Company Services Research and Environmental Affairs, June 1, 2008.

# Initial Geologic Assessment



# $ECO_2S$ Geologic Studies

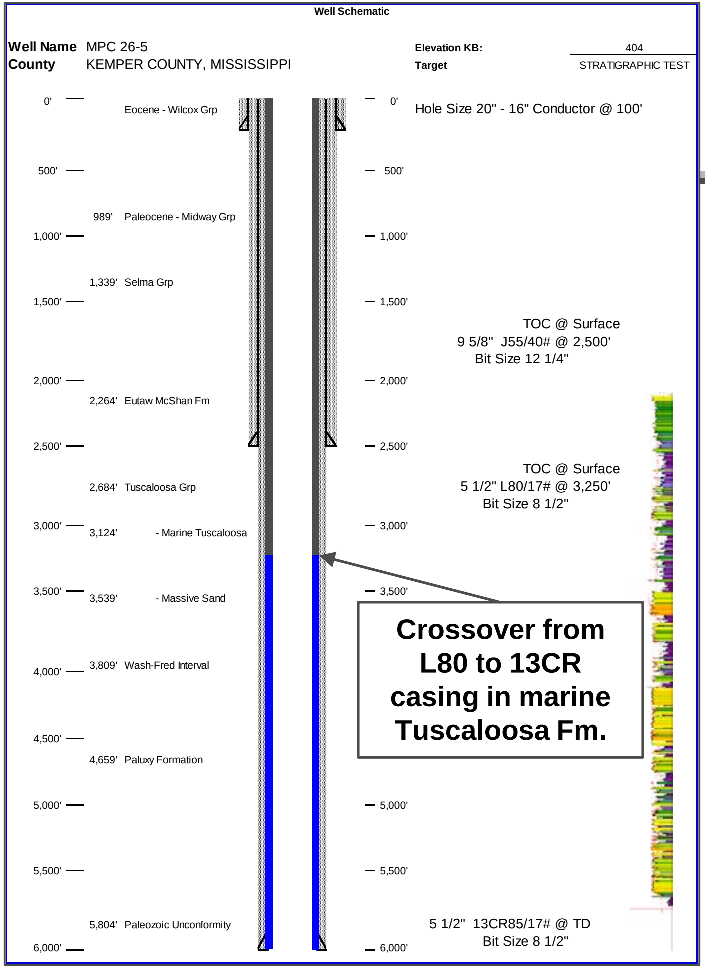
- **Confirm storage reservoir volumetric properties; develop dataset on flow properties (ARI)**
  - Geophysical log response (ARI & Oklahoma State University)
  - Petrophysical properties observed in core (ARI & Oklahoma State University)
  - Advanced core tests, including rel-perm, CT scans under steady-state flow (ARI & University of Wyoming)
- **Caprock studies including (University of Alabama at Birmingham)**
  - Threshold pressure tests, minimum capillary displacement pressure
  - Clay mineralogy
- **Describe depositional facies, rock types, mineralogy, facies and environments of deposition for storage reservoirs and caprocks (Oklahoma State University)**
- **Develop a conceptual geologic model honoring interpreted depositional style (Oklahoma State University & Mississippi State University)**
- **Develop initial rock mechanics model (Mississippi State University)**
- **Extend evaluation to regional framework (Mississippi State University & Virginia Polytech Institute)**
- **Fluid-rock interactions (Auburn University)**
- **Evaluation of existing 2D data, Identify any structural concerns (Geologic Survey of Alabama)**

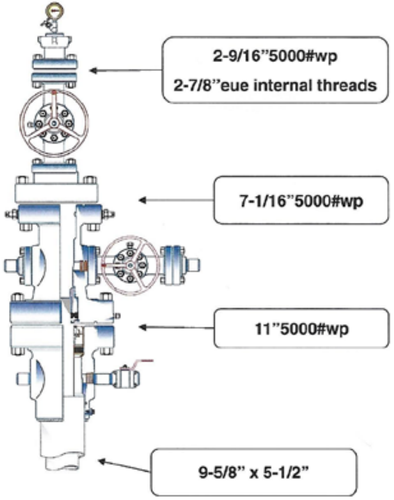
# ECO$_2$S Geologic Data Gathering

- Drill (3) three wells to gather drilling performance data, whole and sidewall core, and geophysical logs
- Openhole geophysical Logs:
  - Triple combo (caliper, array induction, gamma ray, density porosity, neutron porosity, spontaneous potential, photoelectric)
  - Combined magnetic resonance (CMR)
  - Formation micro imager (FMI)
  - Dipole sonic (mechanical properties)
- Whole core and rotary sidewall cores of both reservoir and caprock intervals
- Evaluation of existing 2D seismic
- All combined with literature-based informational resources

# Well Design

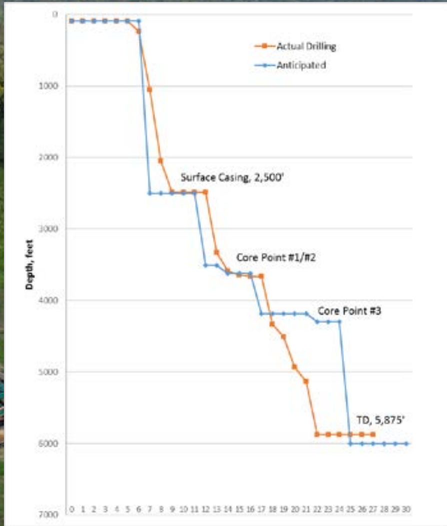
- Crossover from carbon steel to chrome casing in marine Tuscaloosa
- Surface and long string casing cemented to surface



# ECO$_2$S Field Status

- First project well, the MPC 26-5, was spud in May
  - ➢ 17 days from spud to TD including two core points
- Second well, the MPC 34-1, spud in June
  - ➢ 14 days from spud to TD including two core points
- Third well, the MPC 10-4, will be spud in early August




MPC 26-5 – Kittrell Swamp Road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# MPC 26-5 Coring Results

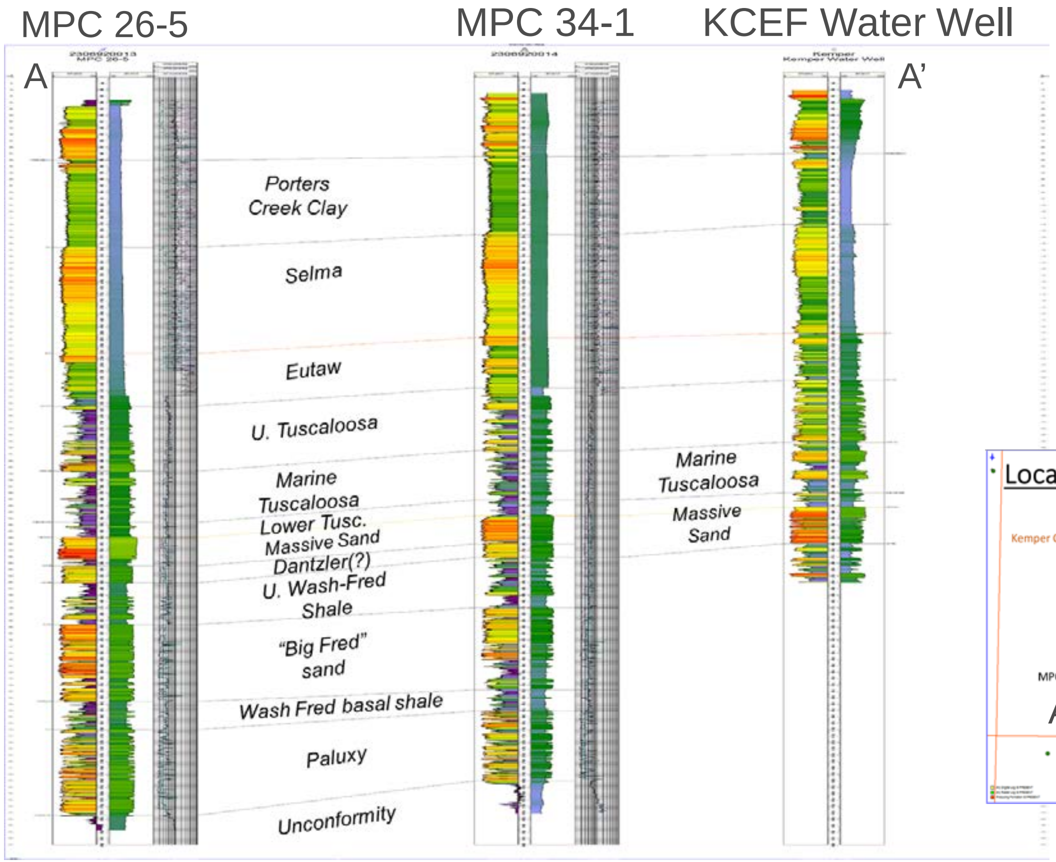
| Core 1 (shale above L.T. massive) | Core 2 (L.T. massive sand) | Core 3 (Wash-Fred) |
|---|---|---|
| • 3,587 – 3,643 ft<br>• Cored 56ft, Recovered 4ft<br>➢ Gray-brown and red-brown shale | • 3,645 – 3,662 ft<br>• Cored 17ft, Recovered 10.5ft<br>• Recovered Portion:<br>➢ Gray to gray-brown shale<br>➢ Medium to fine grained sandstone | • 4,331 – 4,349 ft<br>• Cored 18ft, Recovered 4.3ft<br>• Recovered Portion<br>➢ Medium to fine grained sandstone |

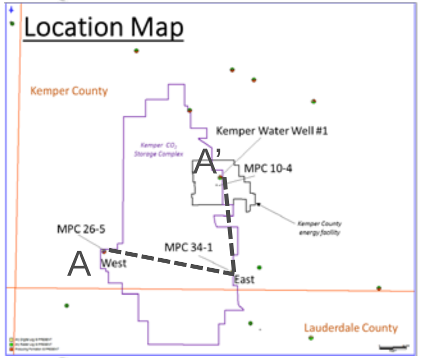
# Core Pictures MPC 26-5

Core 2 Lower Tuscaloosa massive – very poorly indurated sandstone, well caked

Core 3 Wash-Fred – less indurated than Tuscaloosa core

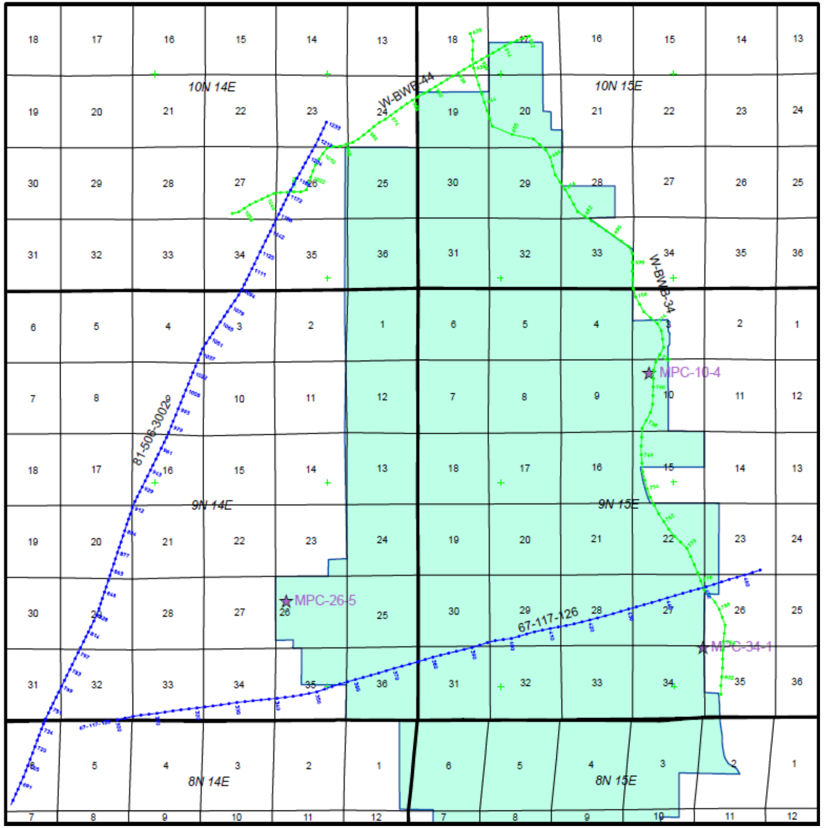
# Storage Complex Reservoir Continuity



# Existing 2D Seismic

- 30 miles of existing 2D seismic was acquired to evaluate structure, regional stratigraphy



# Kemper Storage Complex Capacity

Net thickness* and porosities** from MPC 26-5

| Reservoir | Net Pay (ft) | Porosity |
|---|---|---|
| L. Tusc. Massive | 162 | 28% |
| Wash.-Fred. | 630 | 28% |
| Paluxy Formation | 370 | 26% |
| **TOTAL** | **1,162** | **27%** |

- Calculate $CO_2$ storage capacity at 100% pore volume utilization for 30,000 acres (approximate Kemper Storage Complex area)
- Apply DOE capacity estimate approach with *site specific**** saline formation efficiency factors for clastics of 3.1% (P10), 6.1% (P50) and 10% (P90) (Goodman et al., 2011)

* shale volume less than 20% using gamma ray index
** log density porosity
*** site specific efficiency factors assume that the net/gross area and net/gross thickness terms are fixed at the P90 level

# Kemper Storage Complex Capacity

| Formation | 100% Storage Capacity (MMte)*** | P10 (3.1%) Storage Capacity (MMte)*** | P50 (6.1%) Storage Capacity (MMte)*** | P90 (10%) Storage Capacity (MMte)*** |
|---|---|---|---|---|
| Tusc. Massive Sand | 760 | 20 | 50 | 80 |
| Wash-Fred | 3,140 | 100 | 190 | 310 |
| Paluxy | 1,830 | 60 | 110 | 180 |
| **Total** | **5,720** | **180** | **350** | **570** |

* Assume 0.43 psi/ft hydraulic pressure gradient
** from IPCC 2005 Annex Chart
***million metric tonnes

# Conclusions

The Kemper County Storage Complex appears to be a “world class” $CO_2$ storage prospect!

- Three separate storage reservoirs have exceptional storage capacity with high porosity (up to 30%) and permeability (up to 10 Darcy)
- Reservoirs are vertically confined, increasing the potential for “stacked storage”
- Caprocks are laterally continuous, and have good confining properties
- No structural “show stoppers” or concerns with induced seismicity
- Well drilling is predictable, low risk, and comparatively low-cost
- Large fee-simple property ownership
- Anticipated low commercial-scale storage costs associated with the site
- There is still a lot of work to do!

# Acknowledgements

The Project Team led by Southern States Energy Board, Mississippi Power Company and Southern Company Services, with technical support from Advanced Resources and a host of key subcontractors, acknowledge the valuable support provided by the U.S. DOE National Energy Technology Laboratory on this CarbonSAFE field project.