Southeast Regional Carbon Sequestration Partnership

Pittsburgh, Pennsylvania
October 13, 2005

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Southeast Regional Carbon Sequestration Partnership

Introduction

Gerald R. Hill, Ph.D., SSEB

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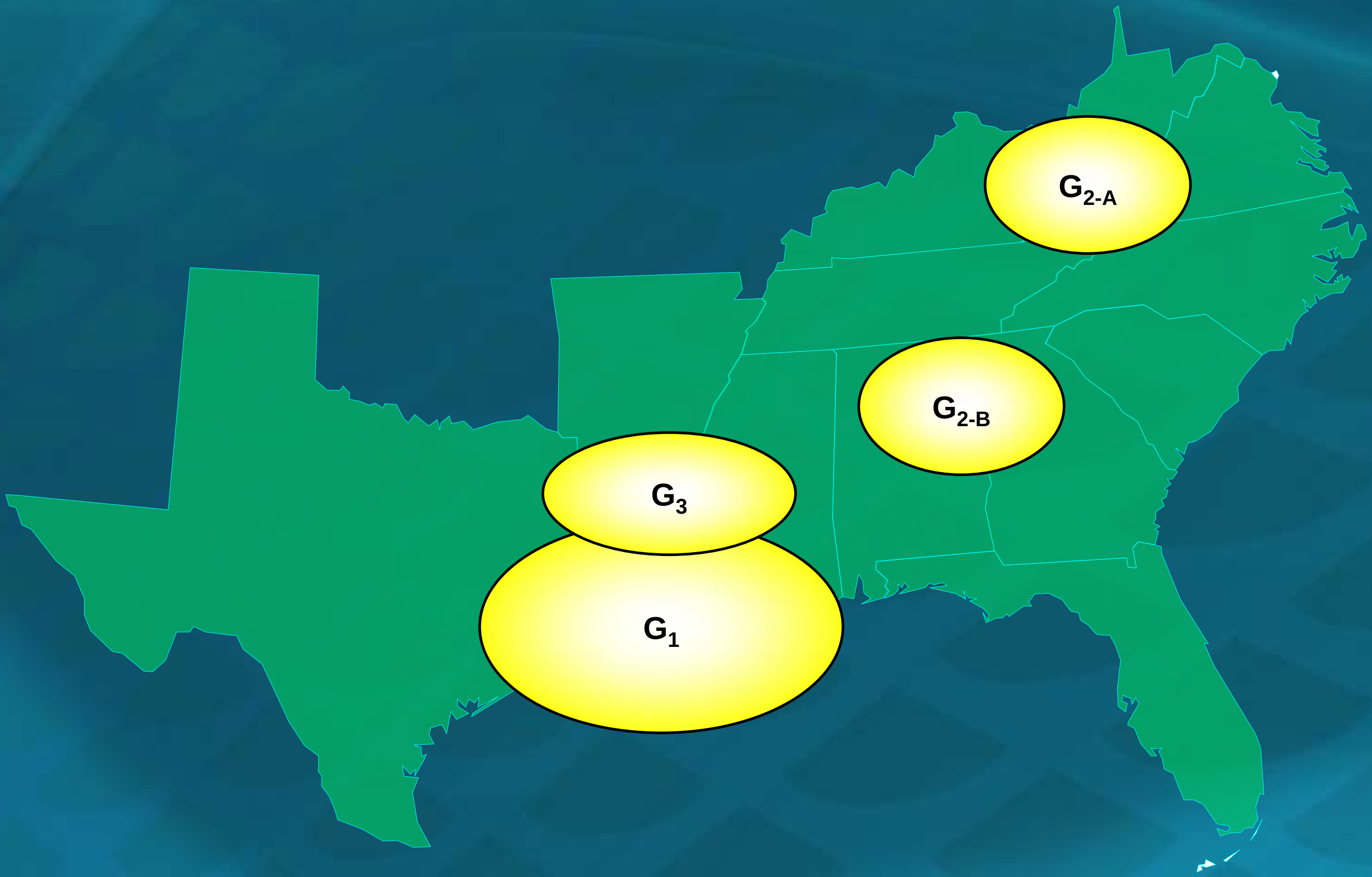
Phase II Goals

- Further characterize the potential carbon sequestration sinks in the Southeast;
- Conduct three field verification studies in some of the most promising geologic formations in the region;
- Advance the state of the art in monitoring, measurement and verification techniques and instrumentation; and
- Have sequestration technologies developed and geologic sinks characterized for future readiness.

SECARB Region & Field Test Site Locations



SECARB Phase II Partners *(in alphabetical order)*

Advanced Resources International
AGL Resources
American Electric Power
Amvest Gas Resources, Inc.
Applied Geo Technologies
Arkansas Oil and Gas Commission
Augusta Systems, Inc.
BP America, Inc.
Buchanan Energy Company of Virginia, LLC
CO_2 Capture Project
CDX Gas, LLC
Center for Energy and Economic Development
ChevronTexaco Corporation
Clean Energy Systems, Inc.
Composite Technology Corporation
CONSOL, Inc.
Core Laboratories
Dart Oil & Gas Corporation
Dominion Energy
Dominion Resources
Duke Power
Eastern Coal Council
Edison Electric Institute
Electric Power Research Institute (EPRI)
Entergy Services
Equitable Production
Florida Power & Light Company
Geological Survey of Alabama
Geological Survey of Kentucky
Georgia Environmental Facilities Authority
Georgia Forestry Commission
Georgia Power Company
Interstate Oil and Gas Compact Commission
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Louisiana Department of Environmental Quality Louisiana Geological Survey
Marshall Miller & Associates
Massachusetts Institute of Technology
McJunkin Appalachian Oilfield Company
Mississippi State University (MSU) - Diagnostic Instrumentation Analysis Laboratory
North American Coal Corporation
North Carolina State Energy Office
Nuclear Energy Institute
Oak Ridge National Laboratory
Old Dominion Electric Cooperative
Phillips Group, The
Pine Mountain Oil & Gas, Inc.
Praxair
Progress Energy
RMB Earth Science Consultants, Ltd.
RMS Strategies
SCANA Energy
Schlumberger
Smith Energy
South Carolina Dept. of Agriculture
South Carolina Electric & Gas Company
South Carolina Public Service Authority/Santee Cooper
Southern Company
Southern Company Services
Southern States Energy Board
Susan Rice and Associates, Inc.
Tampa Electric Company
Tennessee Valley Authority
Texas Bureau of Economic Geology -Gulf Coast Carbon Center
United Company, The
United States Department of Energy/National Energy Technology Laboratory
Virginia Polytechnic Institute and State University
Winrock International

Benefits to the Region

- Increased awareness of the opportunities and challenges associated with carbon sequestration technologies and applications.
- Expanded research efforts in the local, state, federal and private sector communities.
- Increased utilization of clean coal technologies using lower rank coals.

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Presented by:

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Susan Hovorka, Ph.D., TX BEG-GCCC

Jack Pashin, Ph.D., Geological Survey of Alabama

Vello Kuuskraa, Advanced Systems International

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Gulf Coast Stacked Storage Project

Susan Hovorka, Ph.D.,
Gulf Coast Carbon Center, TX-BEG

Gulf Coast Carbon Center

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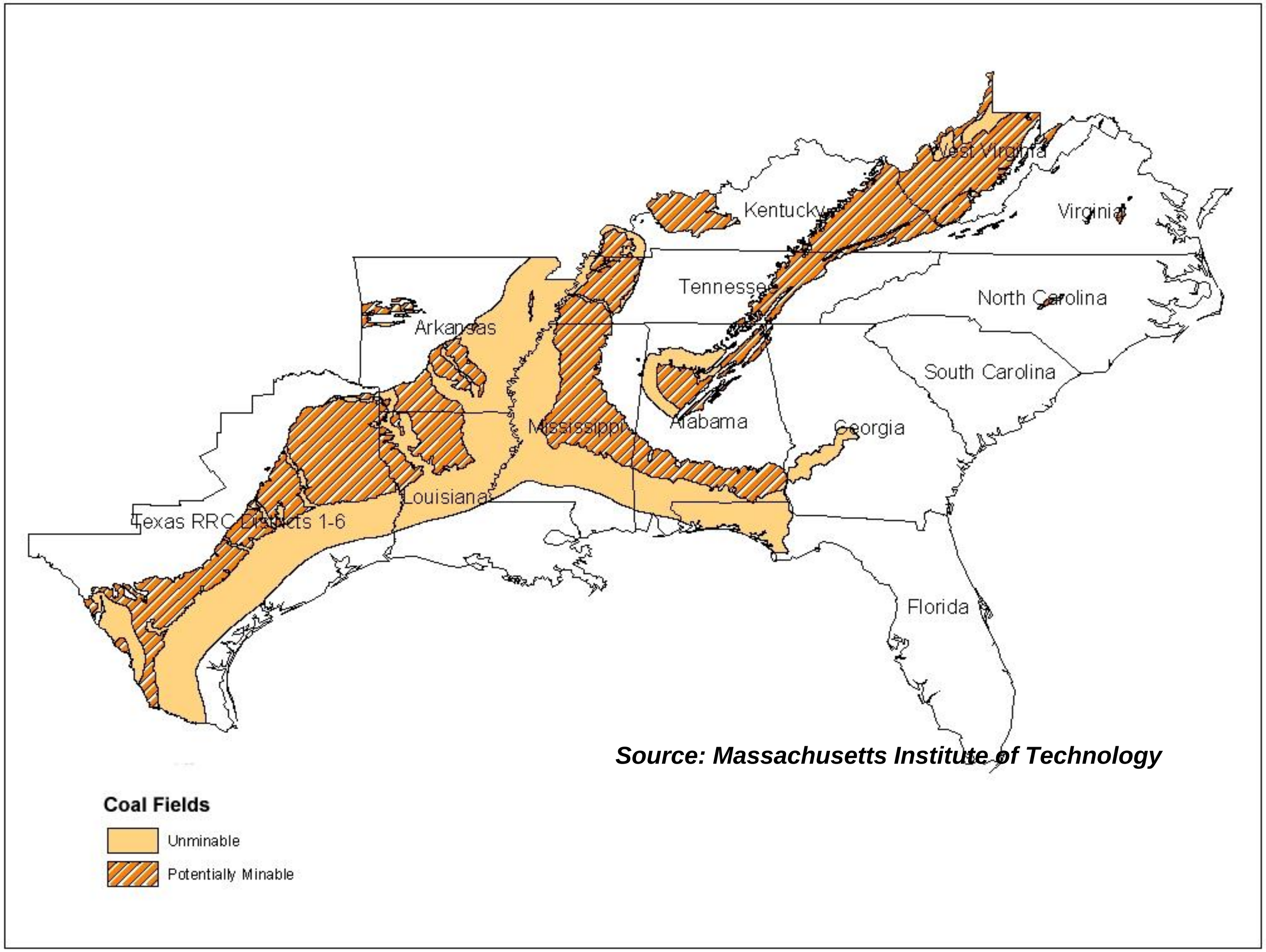
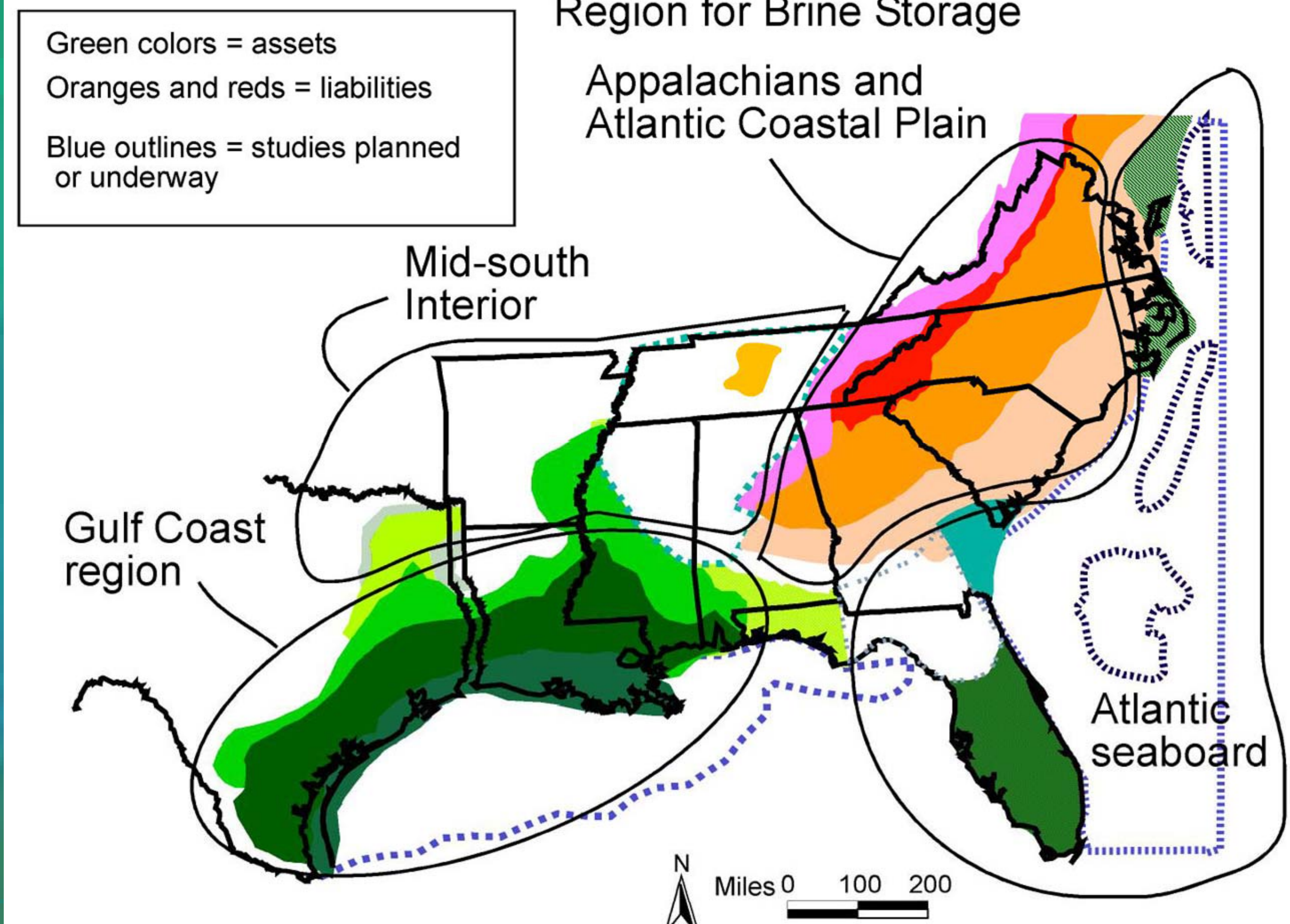
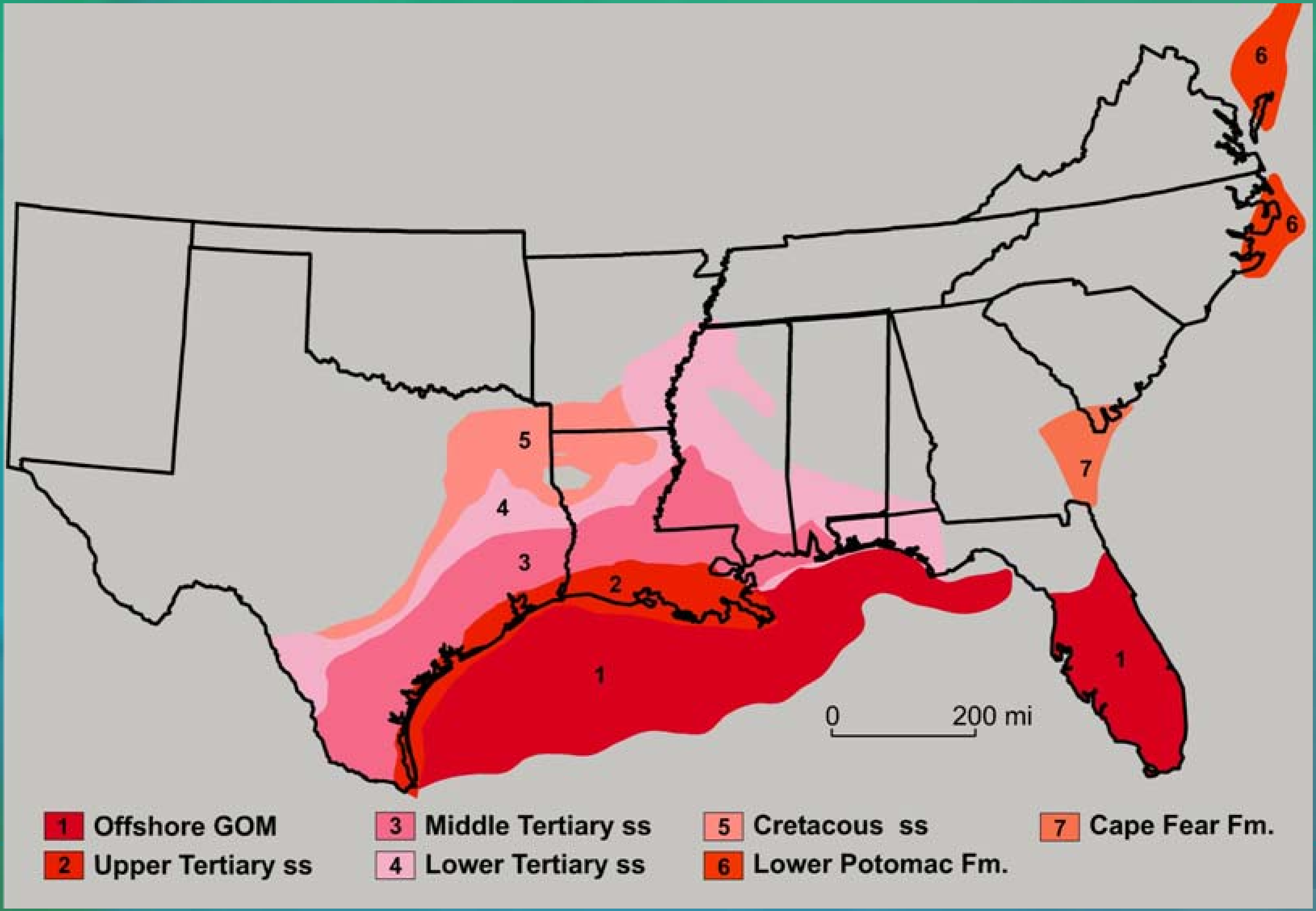
Coal Formation Prospects in Southeast Region



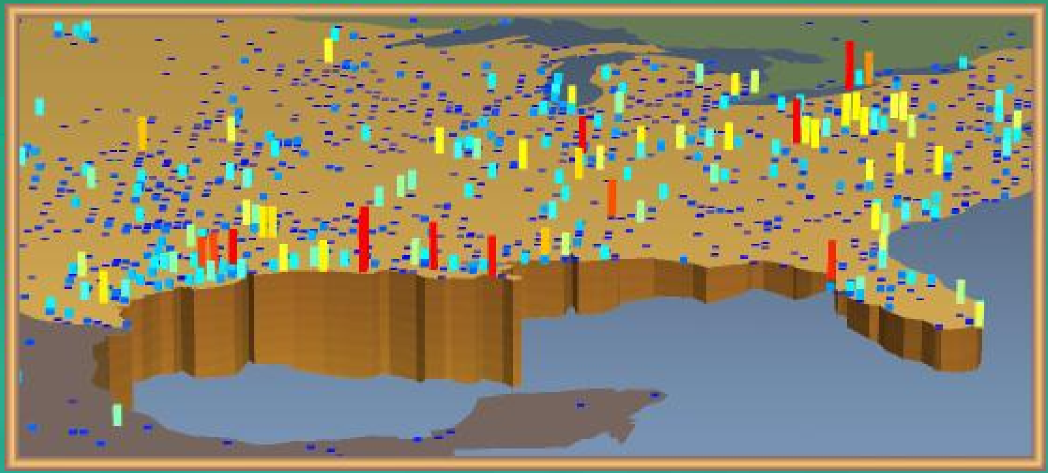
Status of Assessment of the SeCarb Region for Brine Storage



Most Promising Saline Formations



Why apply CCS to the Gulf Coast?



Column height and color show emissions

Brown wedge shows capacity

- The Gulf Coast region accounts for approximately 16% of the U.S. annual CO_2 emissions from fossil fuels.
- Annual emissions of CO_2 in Texas, Louisiana and Mississippi are ~ 1 billion metric tons (1 GT), and Texas alone emits 667 million metric tons of CO_2.
- Source-sink proximity
- “Stacked Sinks”; oil and gas fields overlying large volume brine aquifers
- Regional and local geology is well understood
- Extensive pipeline infrastructure is already in place
- Economic feedback from CO_2 EOR
- Environmental vulnerability

Technology Gaps –

Stacked Storage Field Test Objectives

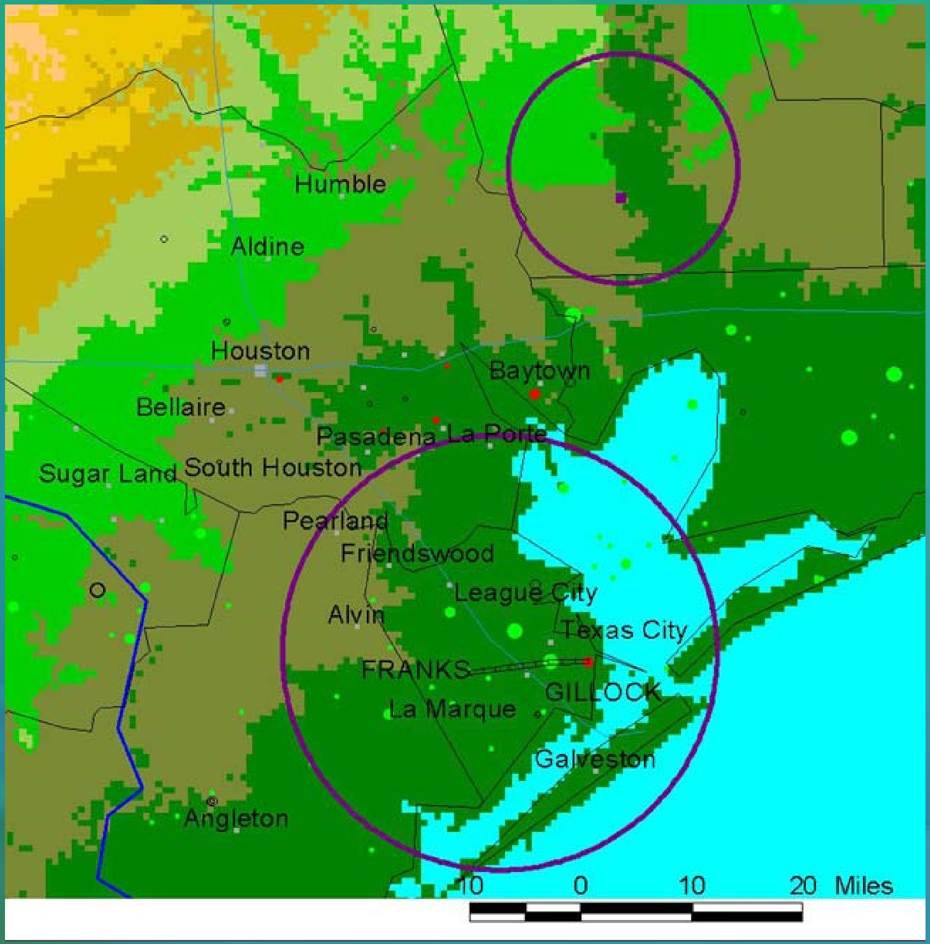
- **Explore options for monitoring permanence at full implementation – define the gold standard for MMV**
- **Data to support risk assessment**
  - Stress conditions during large injection
  - Displacement of brine
  - Impacts at surface – deformation and tilt
- **Improved economic modeling – measure recovery efficiency for current technologies Gulf Coast case specific reservoir**
- **Dual permit for EOR + disposal**

Stakeholders in Stacked Storage Pilot

- **Demonstration that provides value to participants with overlapping objectives:**
  - US carbon storage program – Effectiveness and safety of CCS
  - GCCC industry partners – new markets for products, emissions trading, IP
  - Operator – maximize production

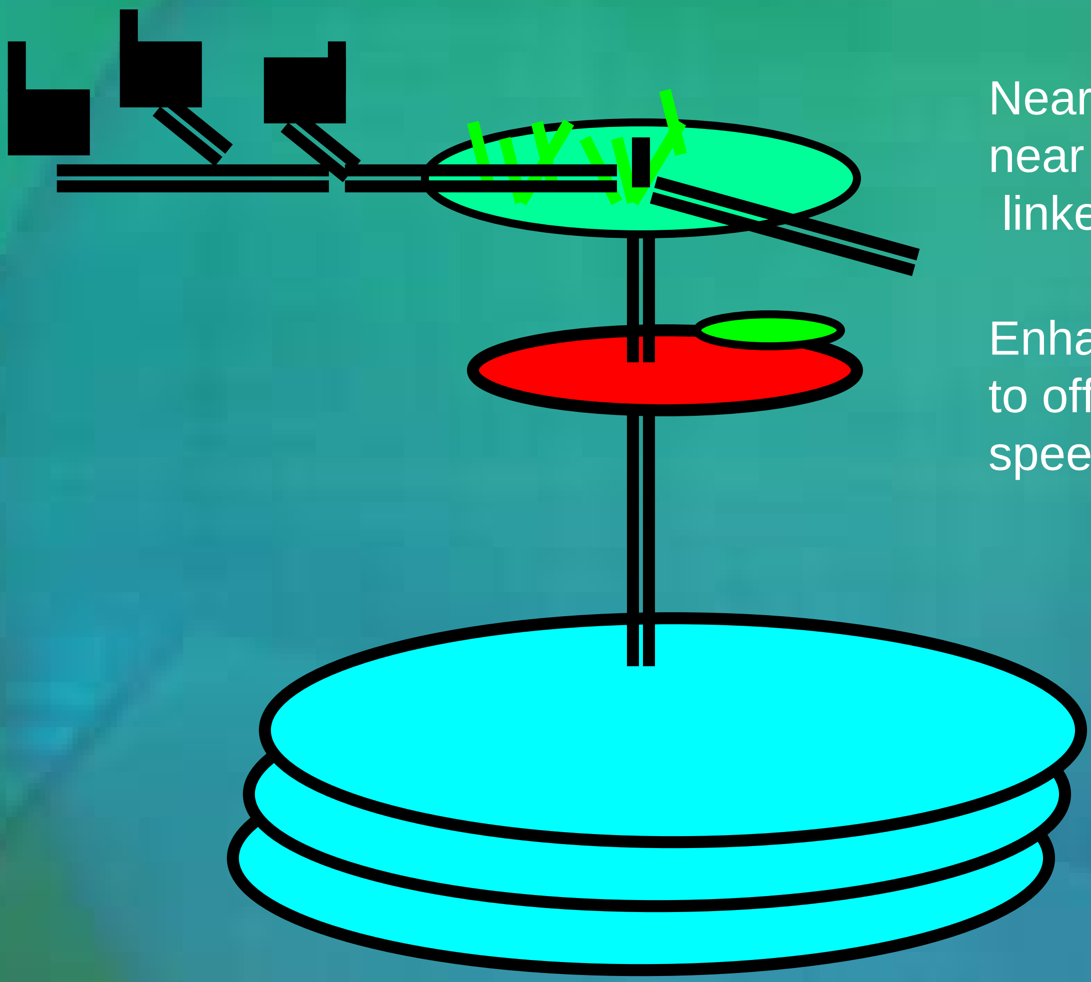
Gulf Coast Carbon Center

Prospective Source-Sink Matches for Stacked Storage



- Source – numerous Texas City refineries, Praxair hydrogen plant
- Sinks – two reservoirs; Smith Energy, Hunt Petroleum, capacity 4 million tons in stacked structural closures, excellent data
- 5-8 mile pipeline
- Coastal lowland, stacked sinks

Geologic Storage Evolution in the Gulf Coast

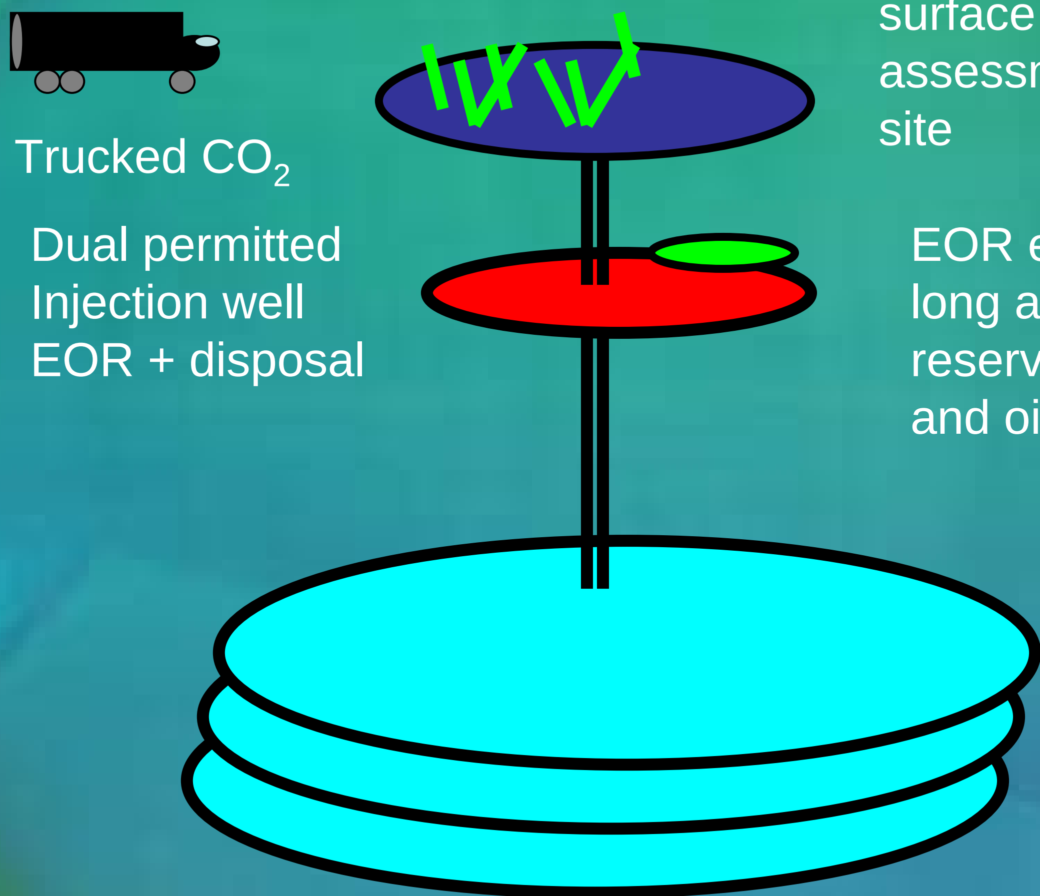


Near-term and long-term sources and near and long-term sinks linked regionally in a pipeline network

Enhanced oil and gas production to offset development cost and speed implementation

Very large volume storage in stacked brine formations beneath reservoir footprints

Environment/Storage/Economic Field Project: MMV Design



Trucked CO_2

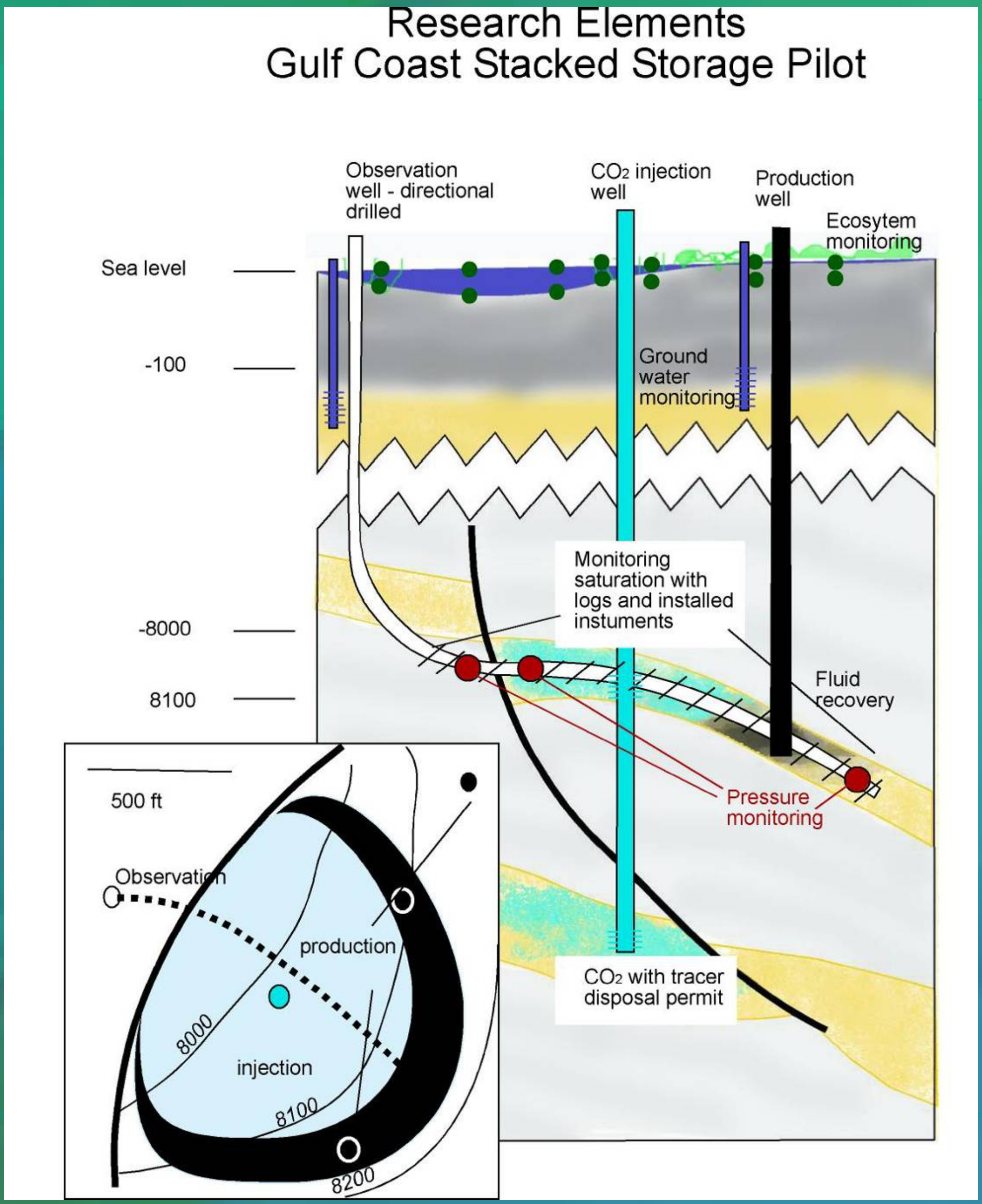
Dual permitted
Injection well
EOR + disposal

Wetlands protection – land surface elevation, risk assessment in high water table site

EOR economics, well leakage risk, long and short term trapping in reservoir by dissolution in water and oil and two phase trapping

Storage in brine – predicting foot print, permanence, fluid displacement interaction with faults, ultimate fate of injectate.

Stacked Storage Monitoring Elements



Ecosystem monitoring: Chemical and biologic change

Ground water monitoring for geochemical change

Injection horizon: pressure, temperature, oil and CO_2 saturation during and post-injection, instrumented slant hole

Characterization of deeper horizon in preparation for eventual disposal

Research Elements

- Demonstration in high emissions area with high injectivity
- Use of CO_2 for EOR – economic demonstration
- Assessment of impacts in of injection in high water table – wetland setting
- Monitoring across a fault and though reservoir to measure CO_2 movement, oil bank formation, pressure evolution, and fluid migration.
- Development of dual use of subsurface for EOR and for disposal

Outreach Elements

- GCCC partners activities
- Technology transfer
- Workshops and symposia
- Extensive technical publications and presentations
- Public outreach – media, web, teacher training, public workshops

Gulf Coast Carbon Center

Gulf Coast Carbon Center

Gulf Coast Carbon Center

Mission: ***A global leadership position in economic implementation of large scale greenhouse gas sequestration.***

GCCC Team

Ian Duncan, Bill Ambrose, Susan Hovorka, Mark H. Holtz, Shinchi Sakurai, Joseph Yeh, Khaled Foaud, Jeff Paine, Becky Smyth, Cari Breton

Mike Moore, Falcon Environmental; Michelle Foss, Center for Energy Economics

Sponsors

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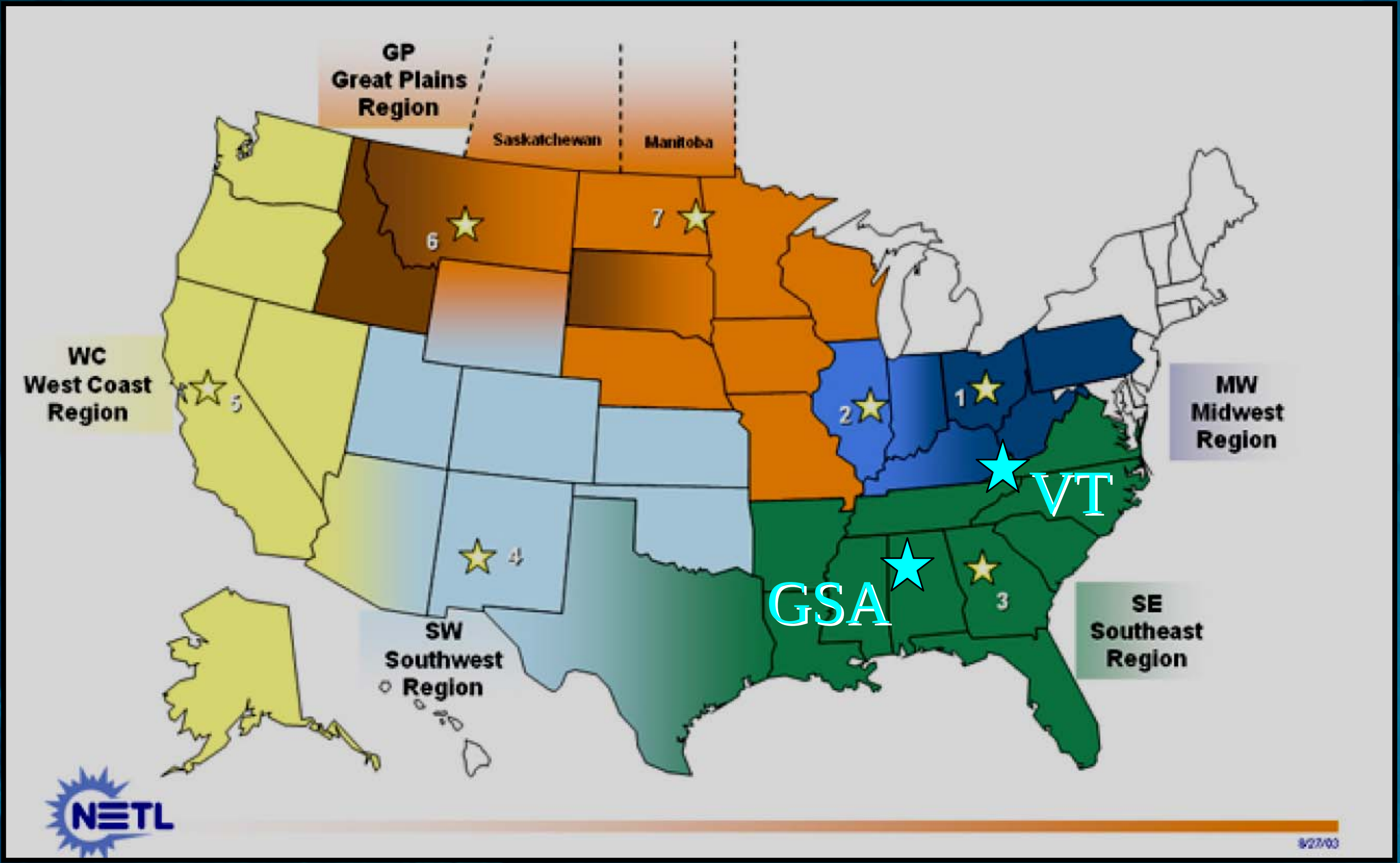
Southeast Regional Carbon Sequestration Partnership

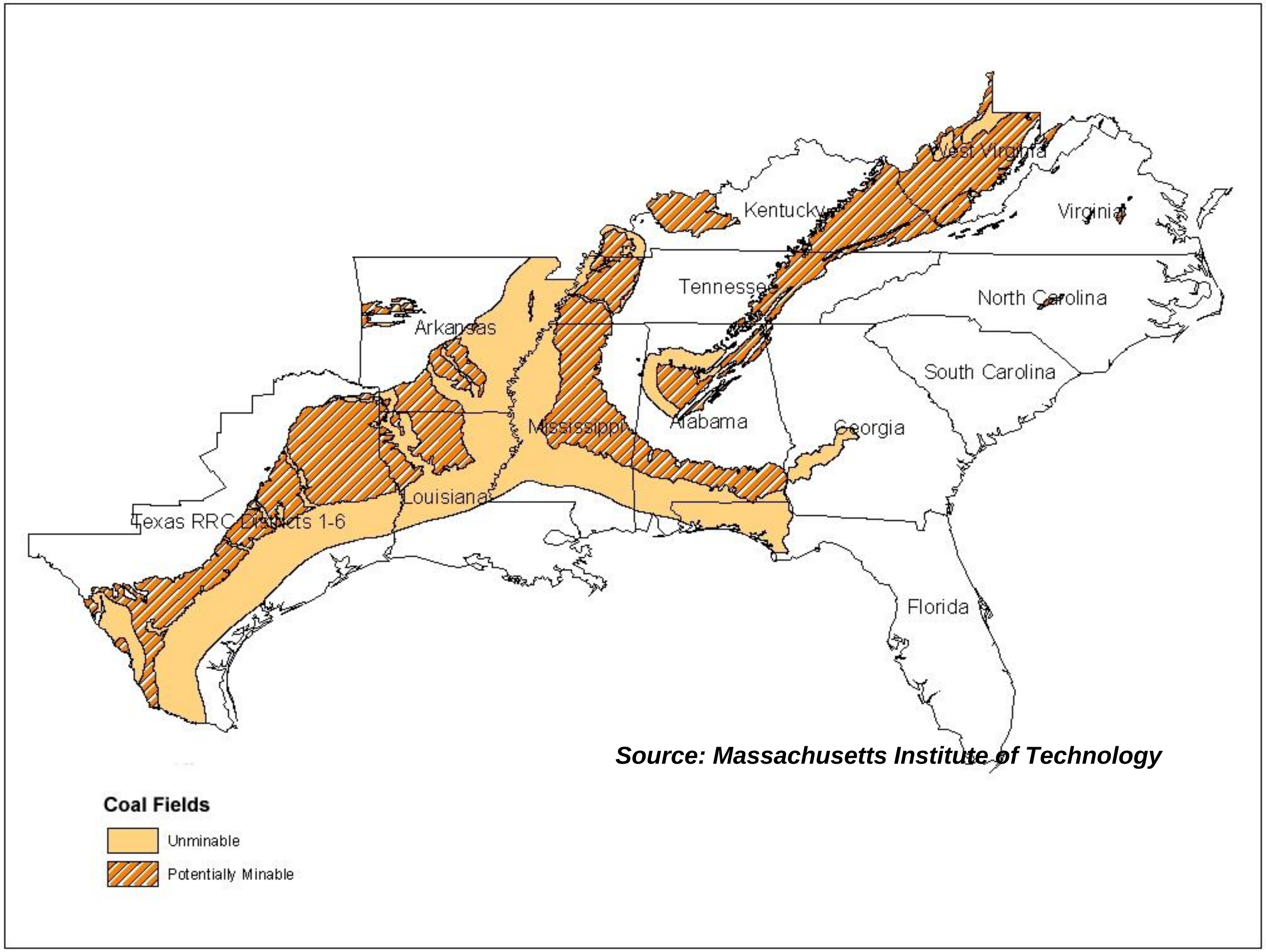
Coal Seam Project

Jack Pashin, Ph.D.,
Geological Survey of Alabama

SECARB Field Tests - Coal

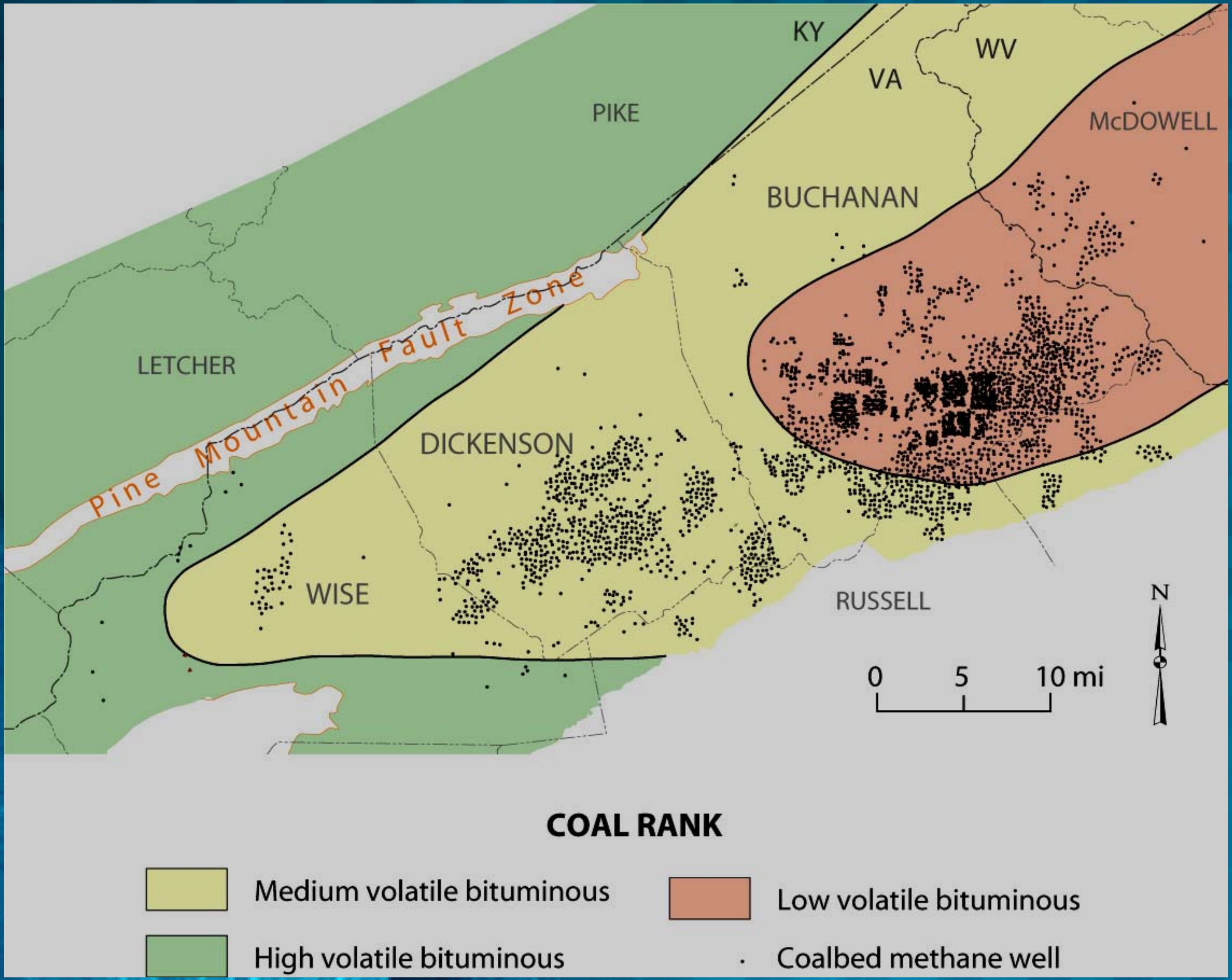


Coal Formation Prospects in Southeast Region

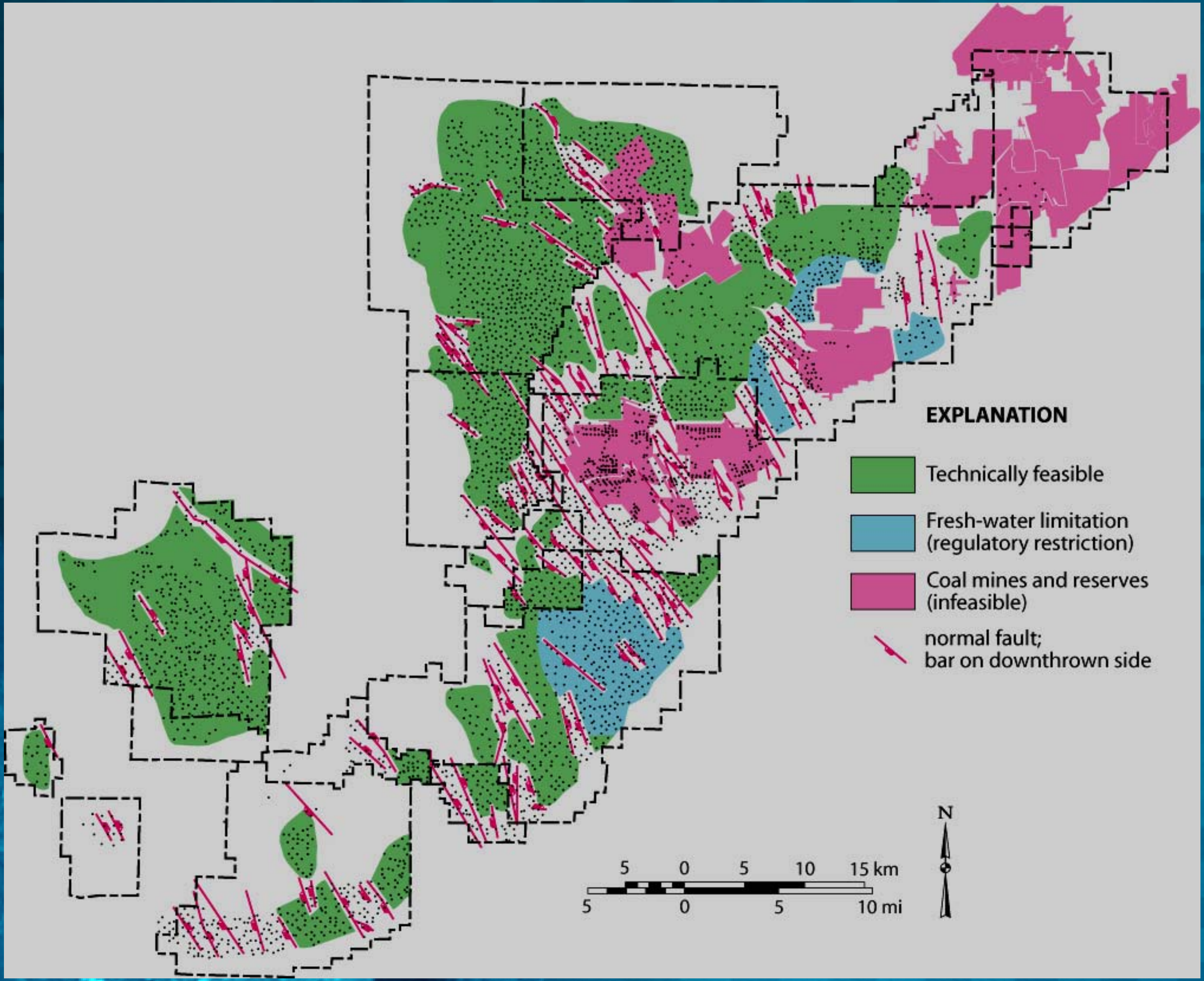


Source: Massachusetts Institute of Technology

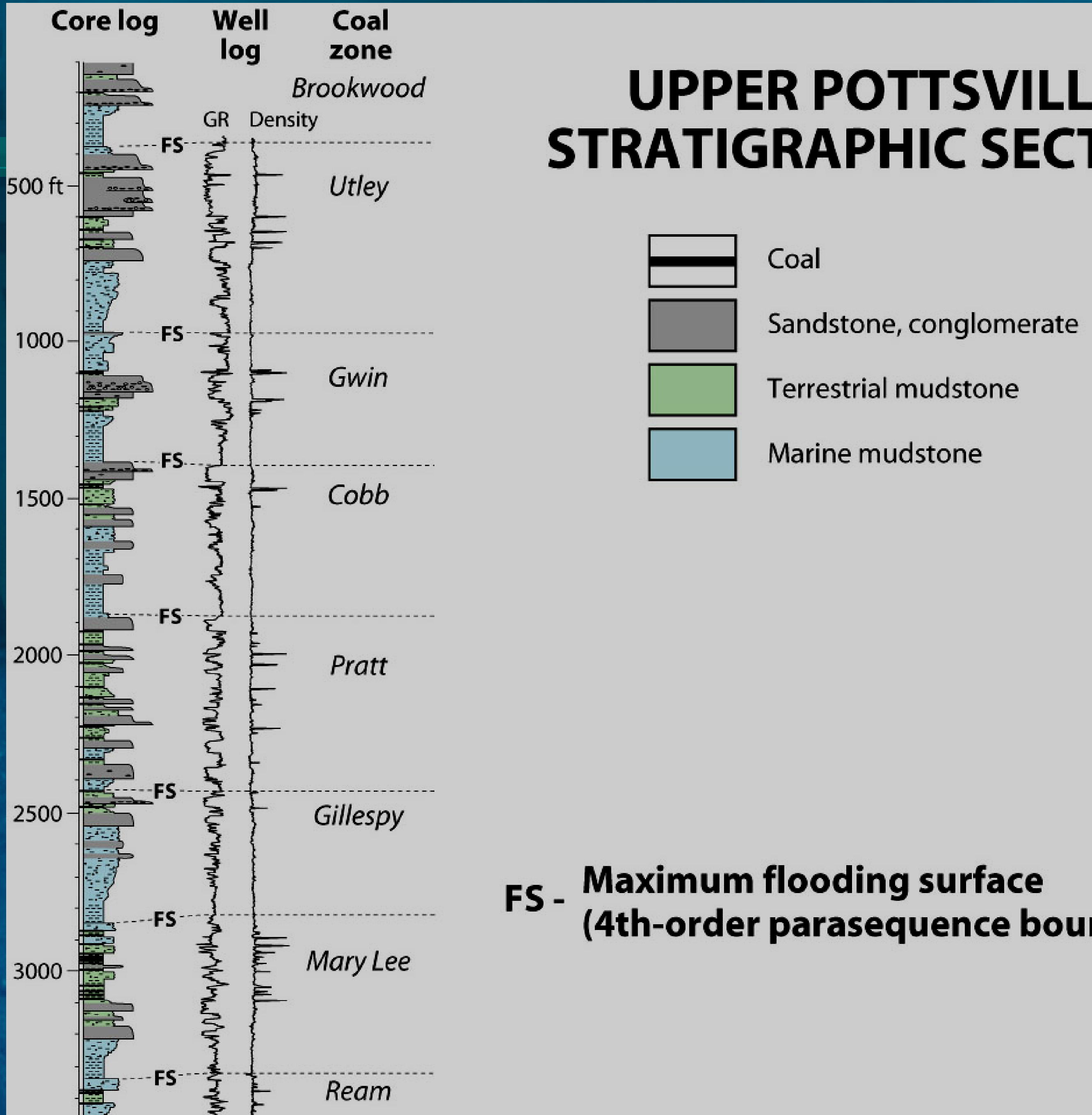
Virginia CBM Development



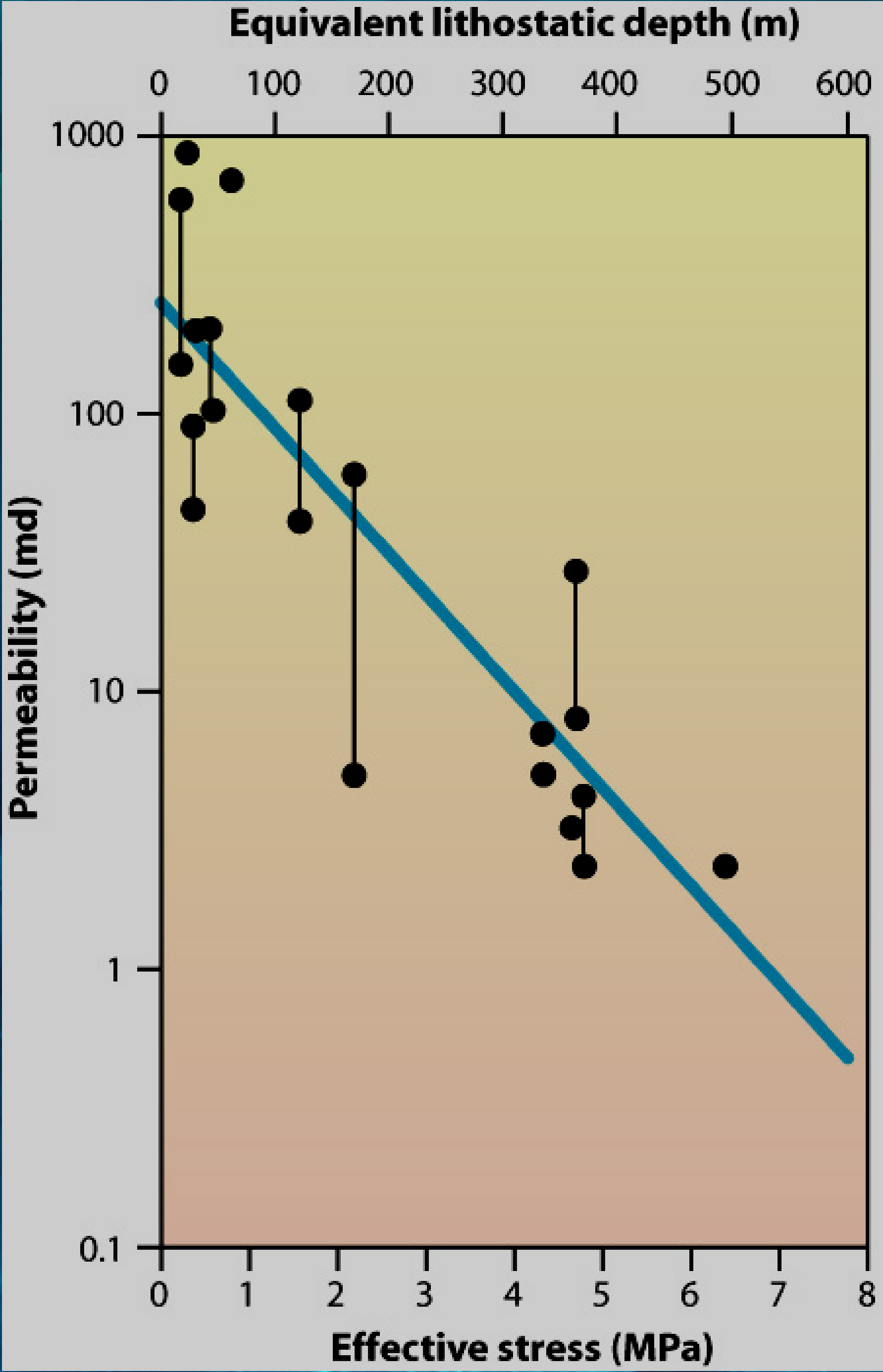
CO_2-ECBM Technical Feasibility - Alabama



UPPER POTTSVILLE STRATIGRAPHIC SECTION



FS - Maximum flooding surface (4th-order parasequence boundary)

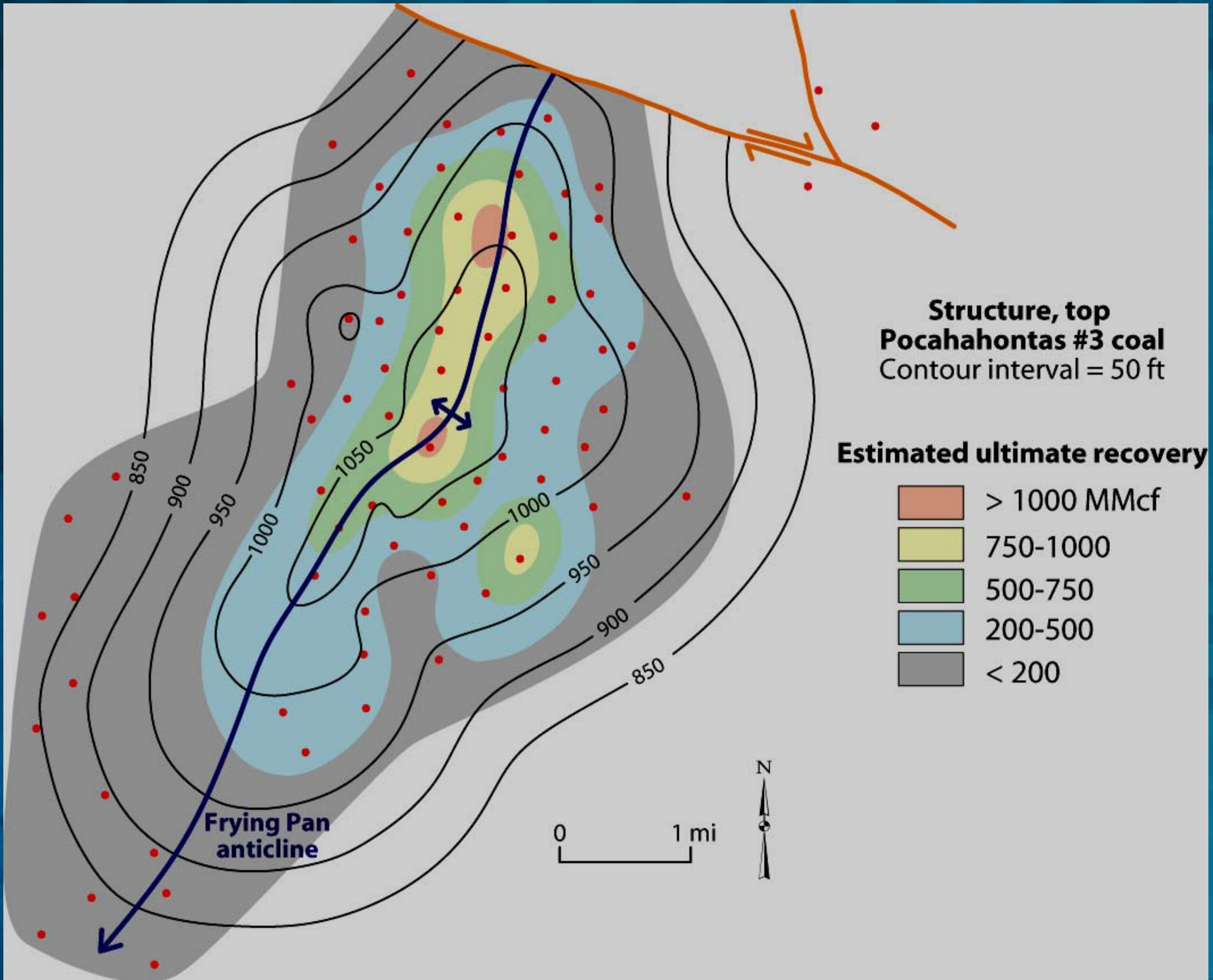


PERMEABILITY-DEPTH RELATIONSHIP

BLACK WARRIOR BASIN

McKee et al., 1988

Anticline, Nora Field, Virginia




Blue Creek Field
N
W
E
S
Image © 2005 DigitalGlobe
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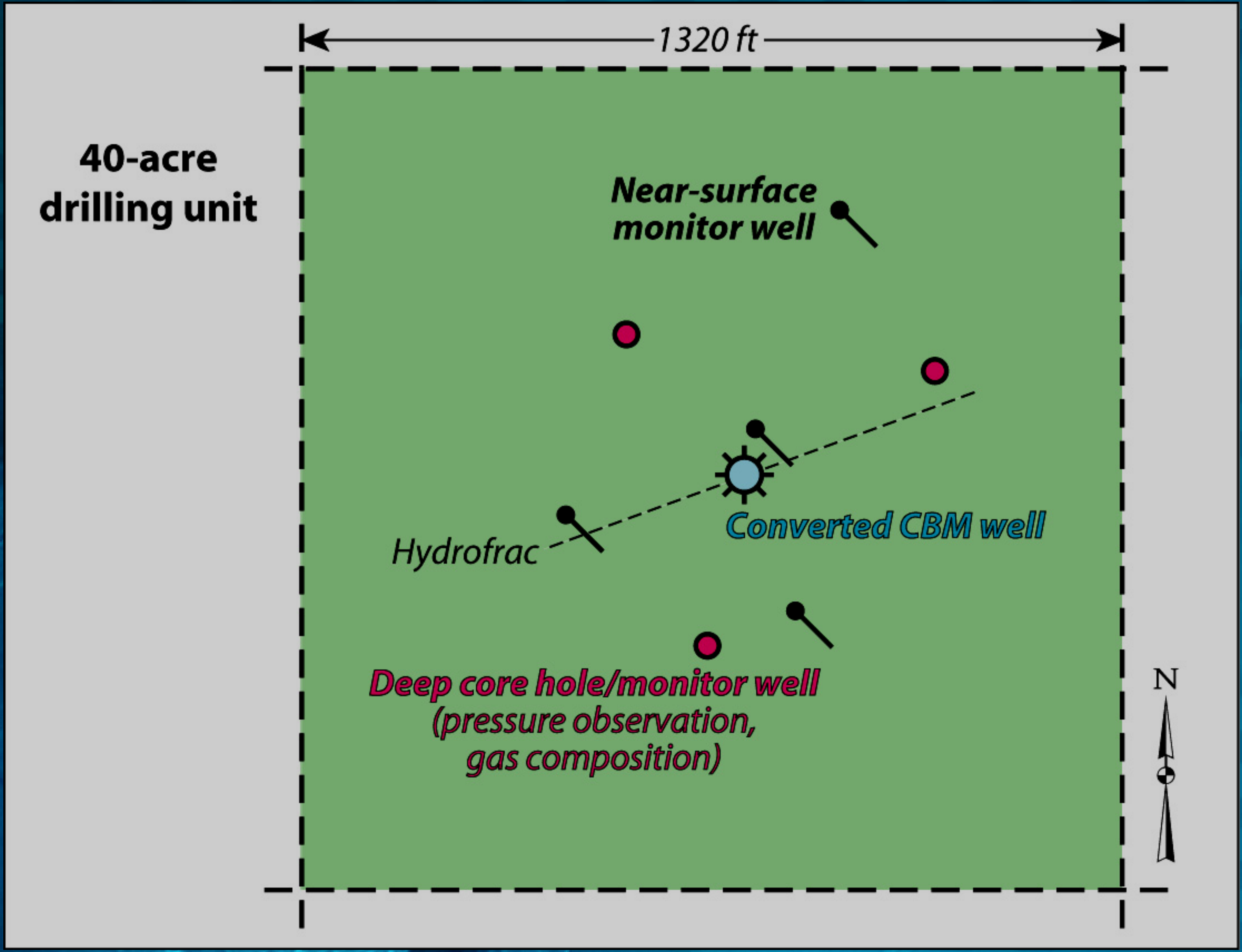
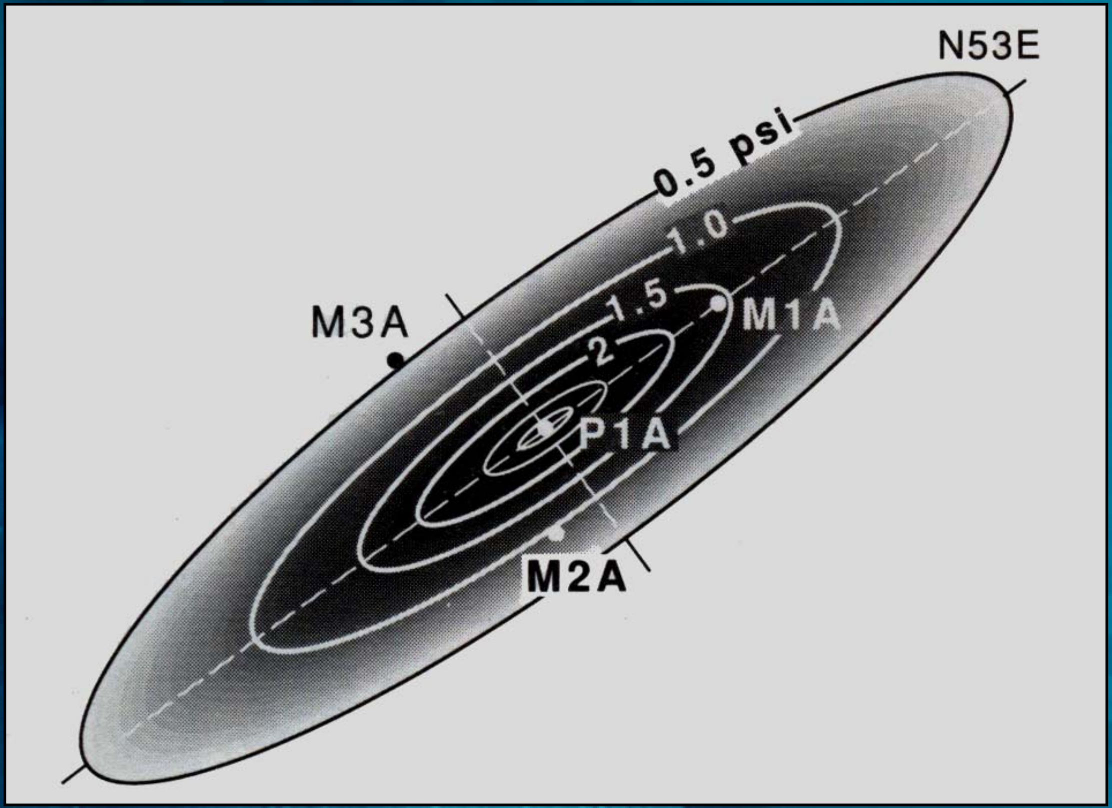
Black Warrior Pilot Site Plan

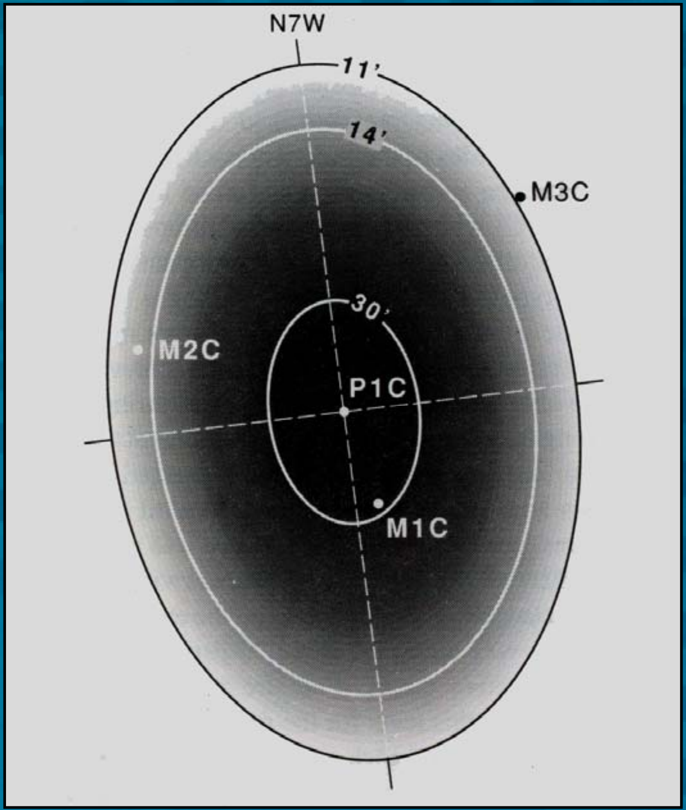


Rock Creek Pressure Buildup Test Results

PRATT COAL



BLACK CREEK COAL

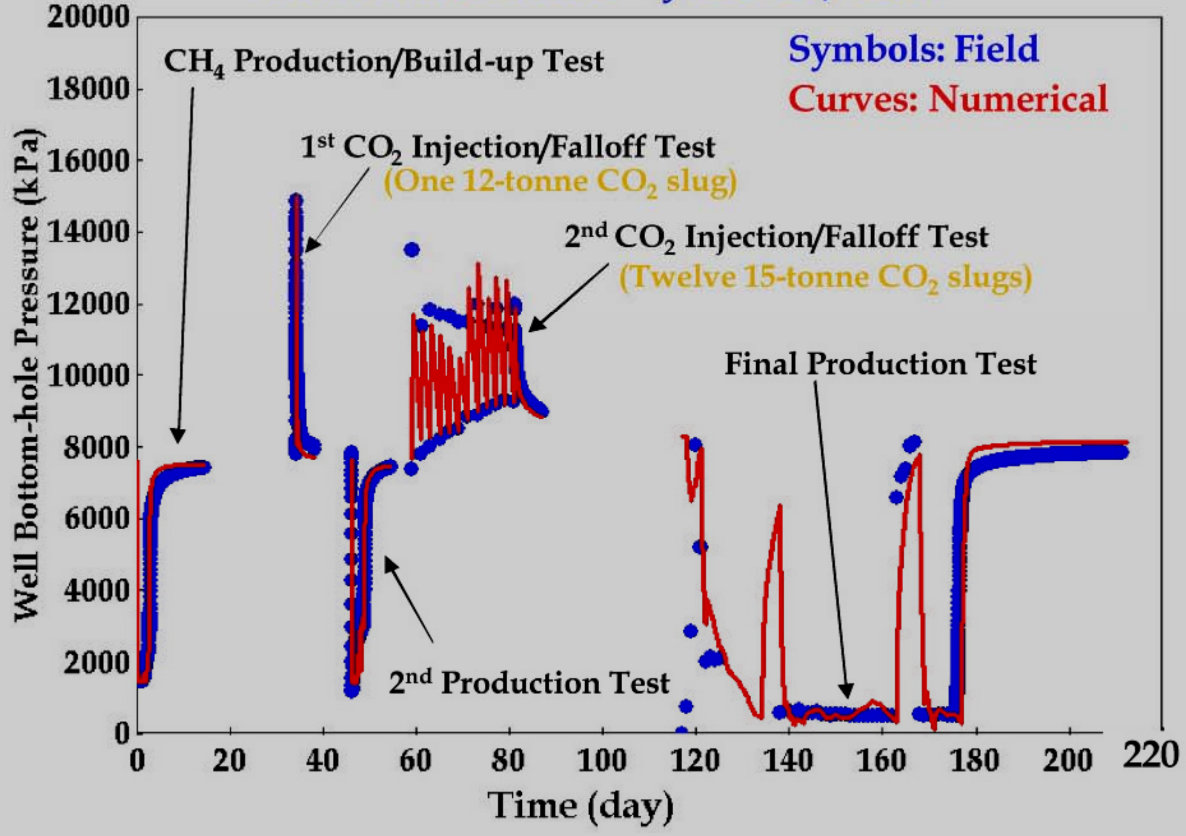


Koenig, 1989

CO_2 Micro-Pilot Test

FVB 4A Well

Reference Time = June 20, 1998



Initial conditions:

- Initial pressure: 7,653 – 7,770 kPa
- Initial gas composition: 91.2% CH_4, 1.8% C_2H_6, 0.3% C_3H_8, 1.6% CO_2, 5.1% N_2
- Absolute permeability: 3.65 md

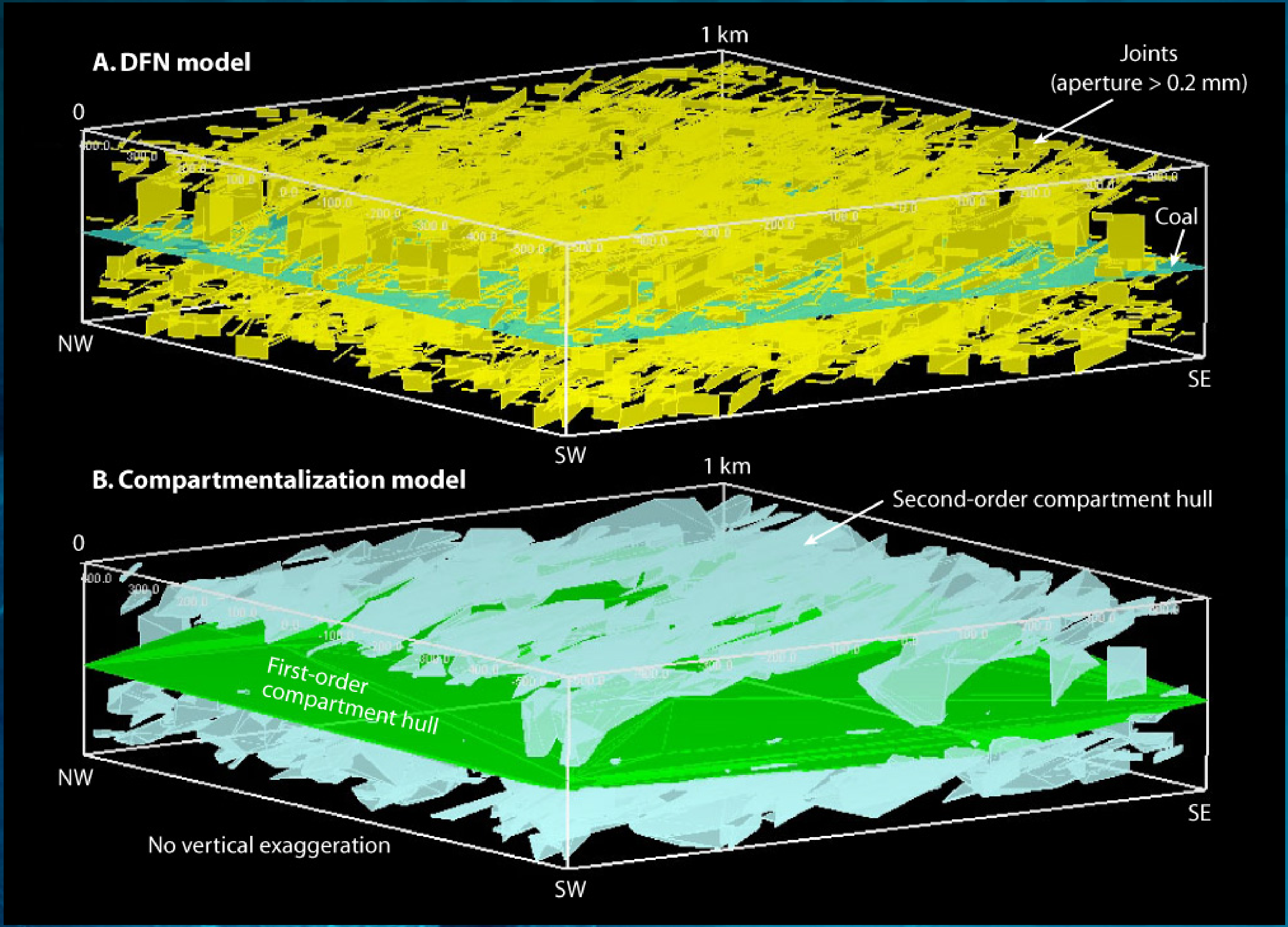
Final conditions:

- Absolute permeability: 0.98 md
- Increase in injectivity: 147%

ALBERTA RESEARCH COUNCIL

Law (2004)

DFN Modeling – Risk Assessment



Outreach

- Stakeholder Advisory Group
- Program Website
- Presentations and Publications
- Workshops and Seminars

Regional Carbon Sequestration Partnerships Review Meeting

Saline Aquifer Test Center Project

Vello Kuuskraa, Advanced Resources International

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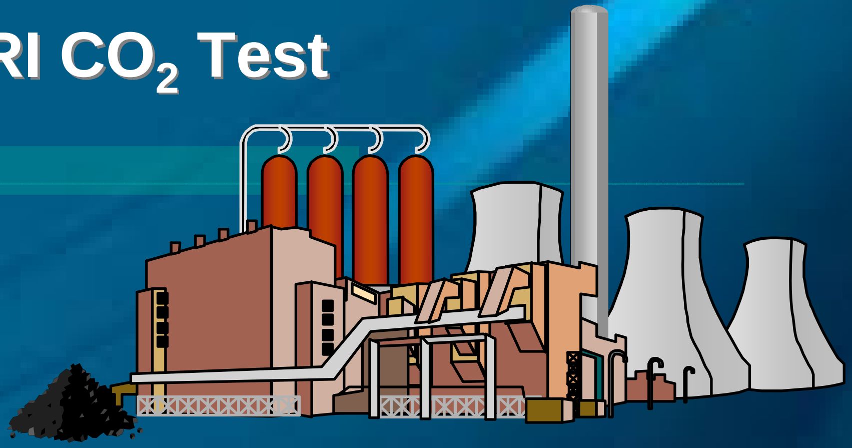
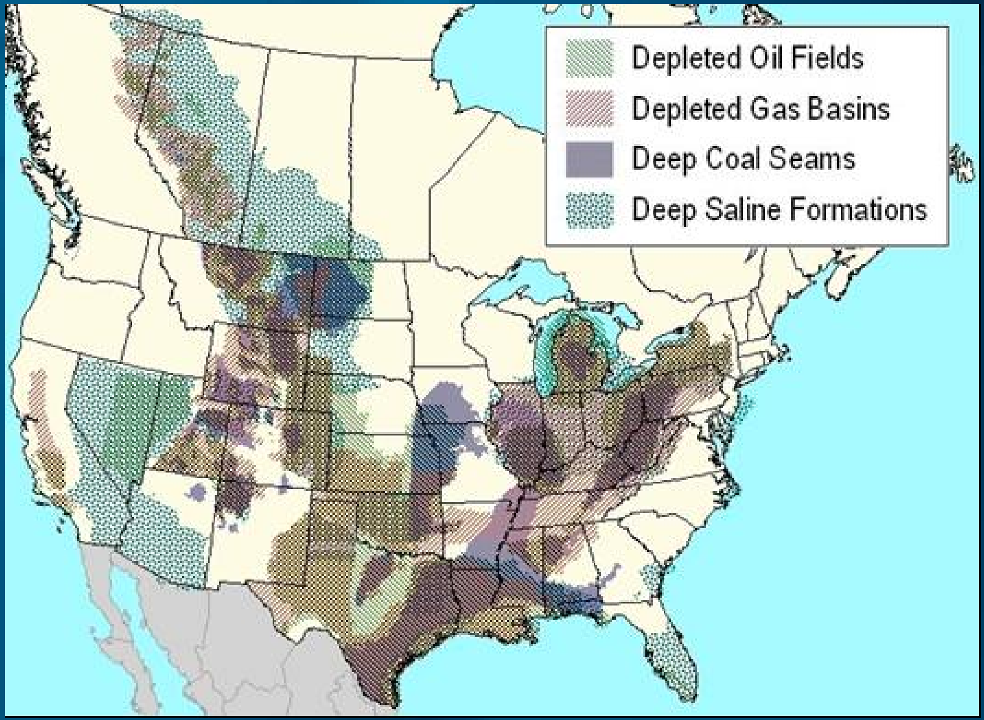
Site Selection Through EPRI CO_2 Test Centers Project



- **Build and operate 2-3 Test Centers**
  - Capture and store CO_2 at 10 MW scale
  - Real operating environments
  - Monitor 1 million tons CO_2 over a 10-year period
- **First site likely an existing PC-fired unit**
  - Results applicable to new PC plants
- **Single well disposal/storage design for initial pilot**
- **Goals include:**
  - Accelerate development of cost-effective options
  - Evaluate technical and environmental issues at a reasonable size
  - Collect long-term data

Potential Sites for EPRI CO_2 Test Centers

- **Sites intended to meet requirements of different regions of U.S.**
- **Phase 1 identified four suitable locations**
  - All Eastern U.S. with saline aquifers
- **One selected for SECARB Phase 2 pilot as also being representative of the region**



Source: IEA GHG Program

Saline Aquifer Test Center Project
Project Overview

- The project's goal is to locate suitable geological sequestration sinks in proximity to the large coal-fired power plants in the region.
- The initial target is the Cretaceous-age Eutaw Formation, which has a large potential CO_2 storage capacity.
- The project will build detailed geological and reservoir maps of the test site, establish baseline data and conduct a sequence of reservoir simulations to estimate injectivity, storage capacity, and long-term fate of injected CO_2.
- The field test plans to inject approximately 3,000 tons of CO_2 followed by longer term MMV.

Work Plan

Task 1. Project Definition. Build initial geologic and reservoir model and conduct public outreach.

Task 2. Project Design. Procure CO_2 supply (3,000 tons), define MMV protocols and complete regulatory compliance.

Task 3. Project Implementation. Drill, log and test slim-hole reservoir characterization well, gather baseline data and prepare field test site. Drill, complete and test CO_2 injection well.

Task 4. Project Operations. Inject CO_2 (for 30 days), complete MMV protocols and modify reservoir model.

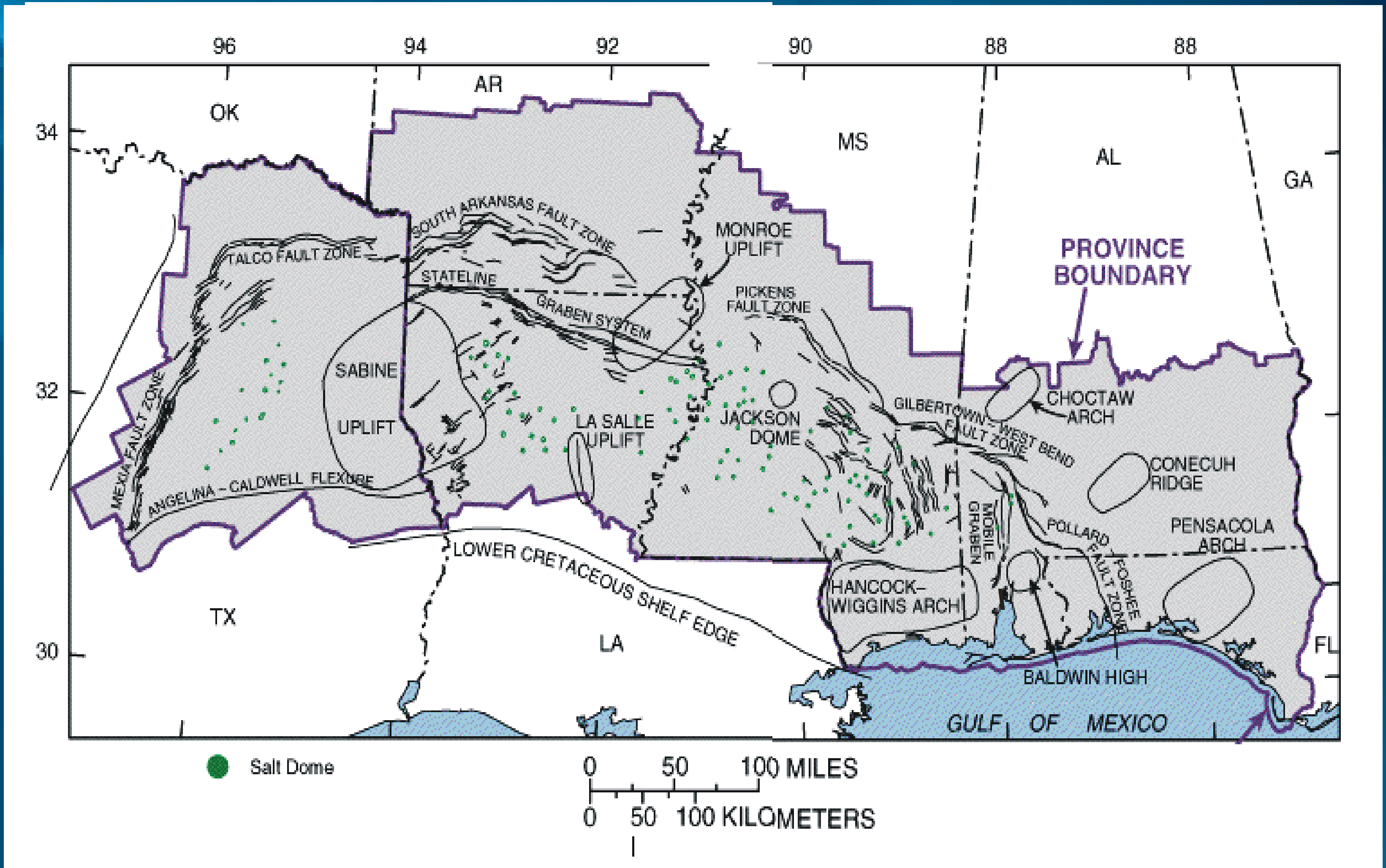
Task 5. Project Completion, Post Appraisal and Report. Extrapolate field test for injectivity, storage capacity and costs of geologic CO_2 storage in SECARB region. Prepare MMV protocols chapter and final reports.

Saline Aquifer Test Center Project
Geologic Setting

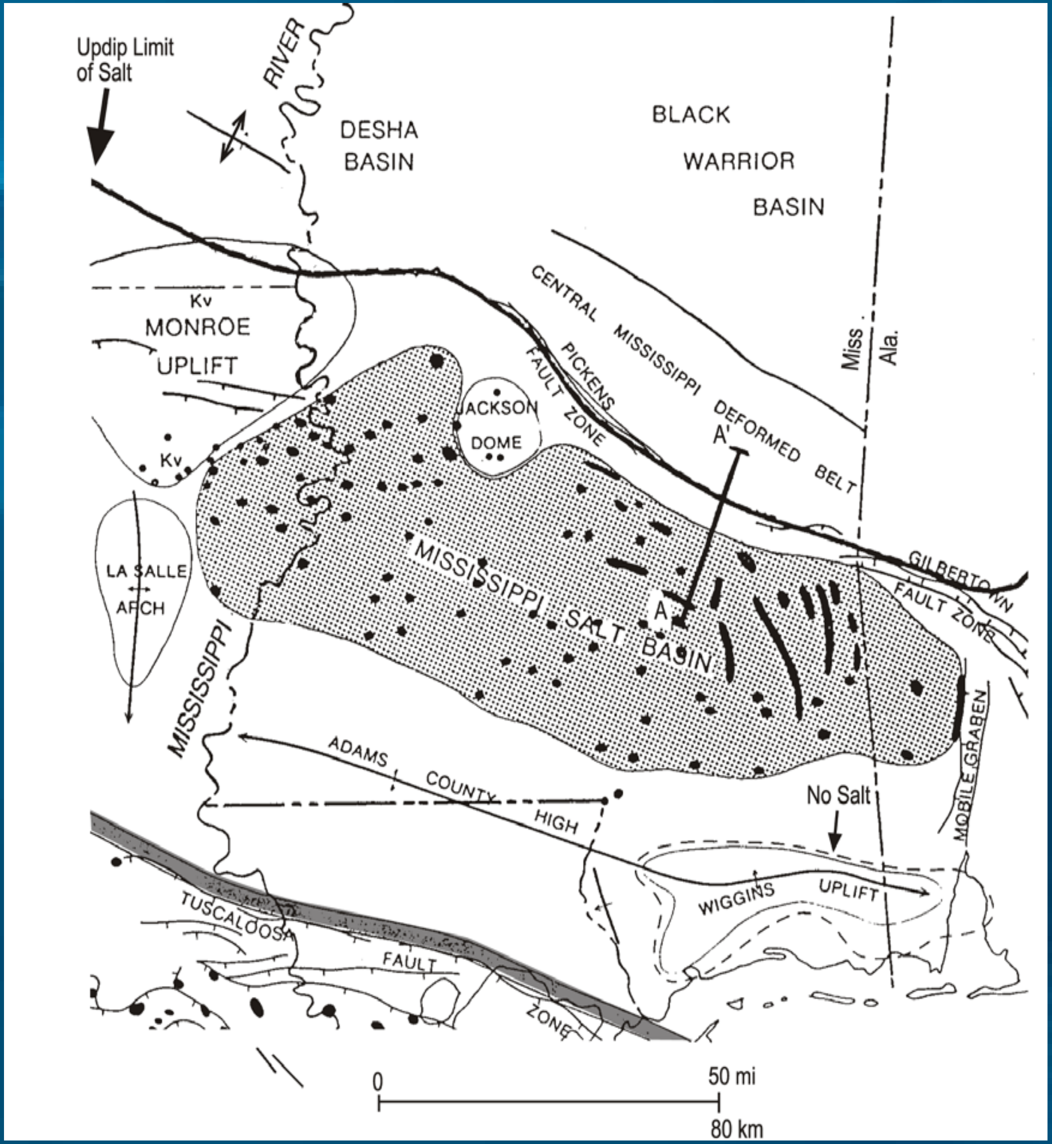
- The Saline Aquifer Field Test G-3 will be conducted in the Mississippi Interior Salt Dome Province.
- The basin is an interior sag characterized by numerous salt related structures, including salt domes, anticlines and piercement domes.
- The stratigraphic section contains over 20,000 feet of Mesozoic through Tertiary-age sediments, primarily sandstones with interbedded shale and limestone.
- The section thickens southward and westward.

Geologic Setting for Field Test G-3

The Mississippi Interior Salt Dome Province
(Source: USGS, 1995)



Regional Tectonic Map for Field Test G-3 Area



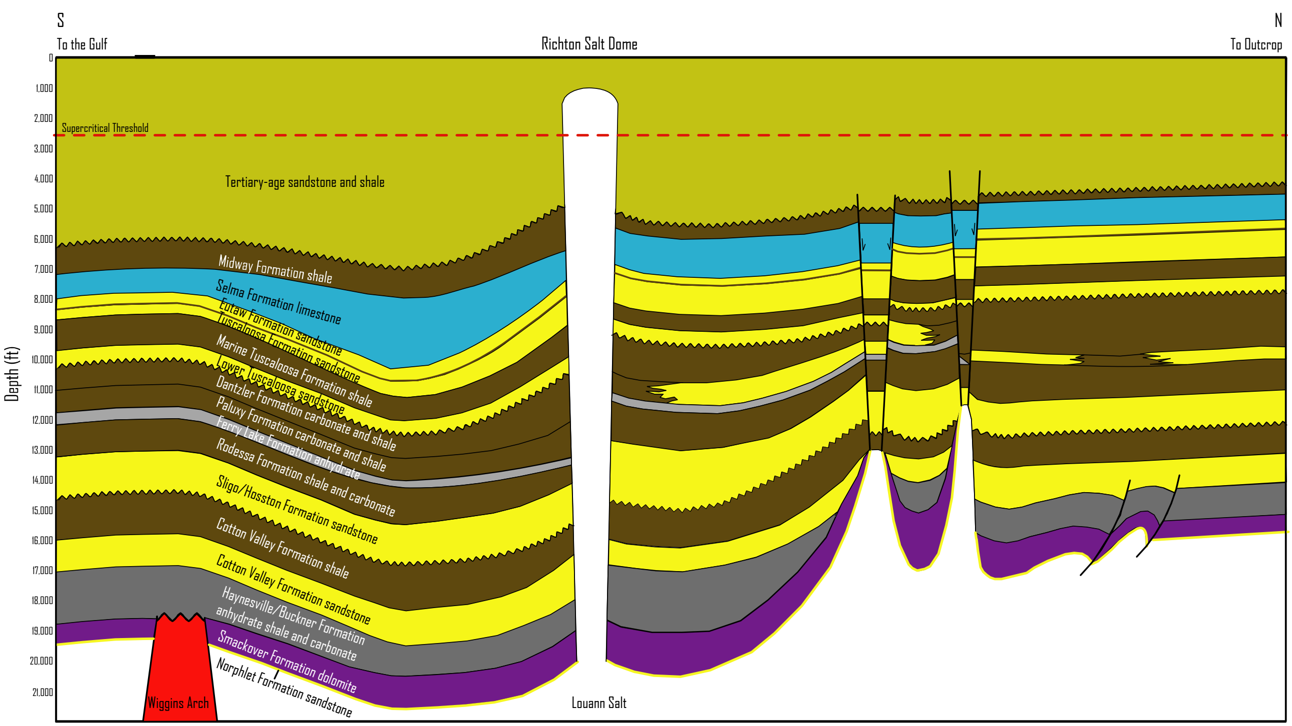
(Source: Montgomery and Ericksen, 1997)

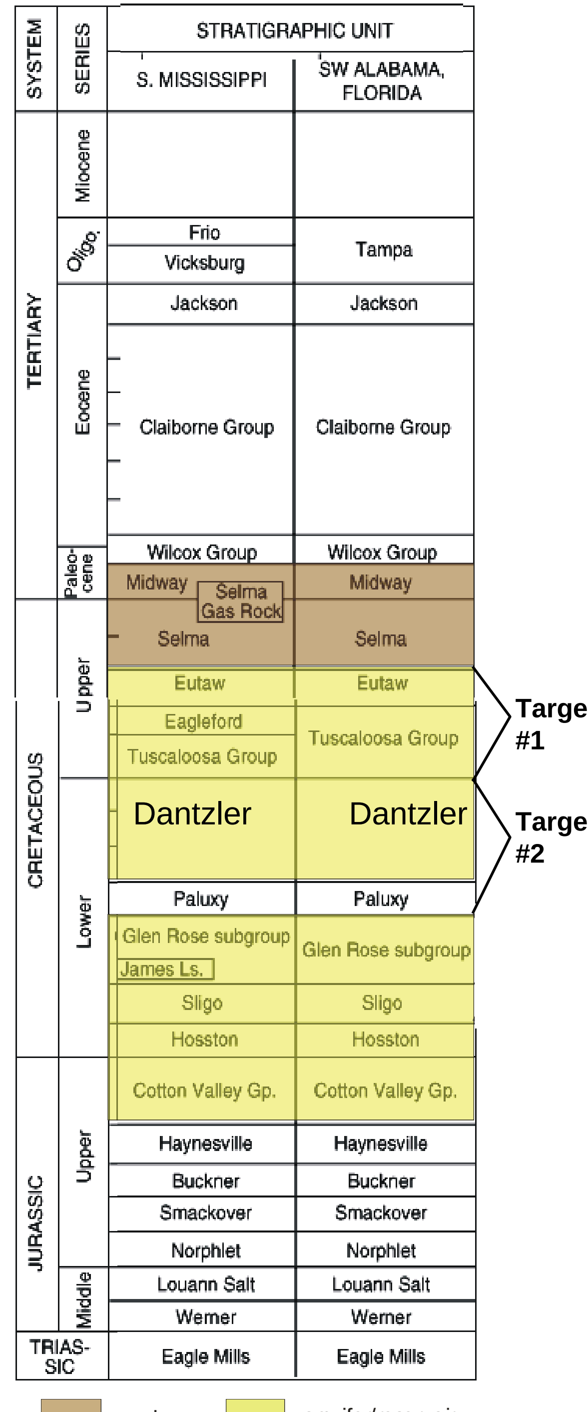
Saline Aquifer Test Center Project
Target Formations

- **The Cretaceous-age sandstone aquifers, at depths of 6,000 to 10,000 feet, are the initial target for storing CO_2. The formations include:**
  - Eutaw/Tuscaloosa (400 to 600 feet, 30% porosity, 500 md)
  - Dantzler/Paluxy (300 to 1,000 feet, 25% porosity, 1,000 md)
- **Approximately 2,000 feet of shale and shaley limestone in the Midway and Selma (plus Lower Tuscaloosa) formations serve as the confining unit.**

Geologic Cross Section of the Field Test G-3 Area

(Source: Advanced Resources International, 2004 based on Williams, 1969)





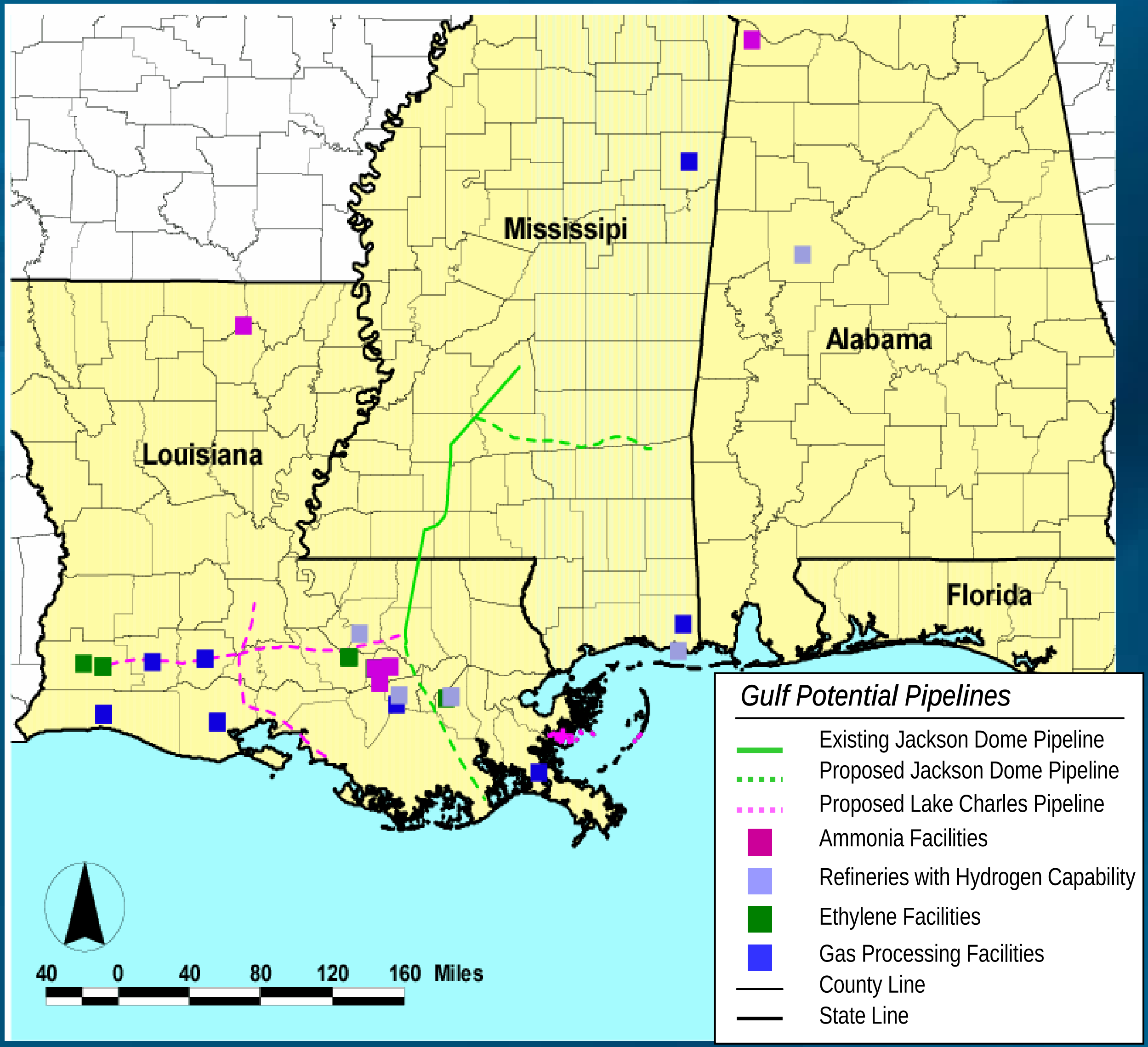
STRATIGRAPHY OF THE MISSISSIPPI SALT BASIN PROVINCE

(Source: USGS, 1995)

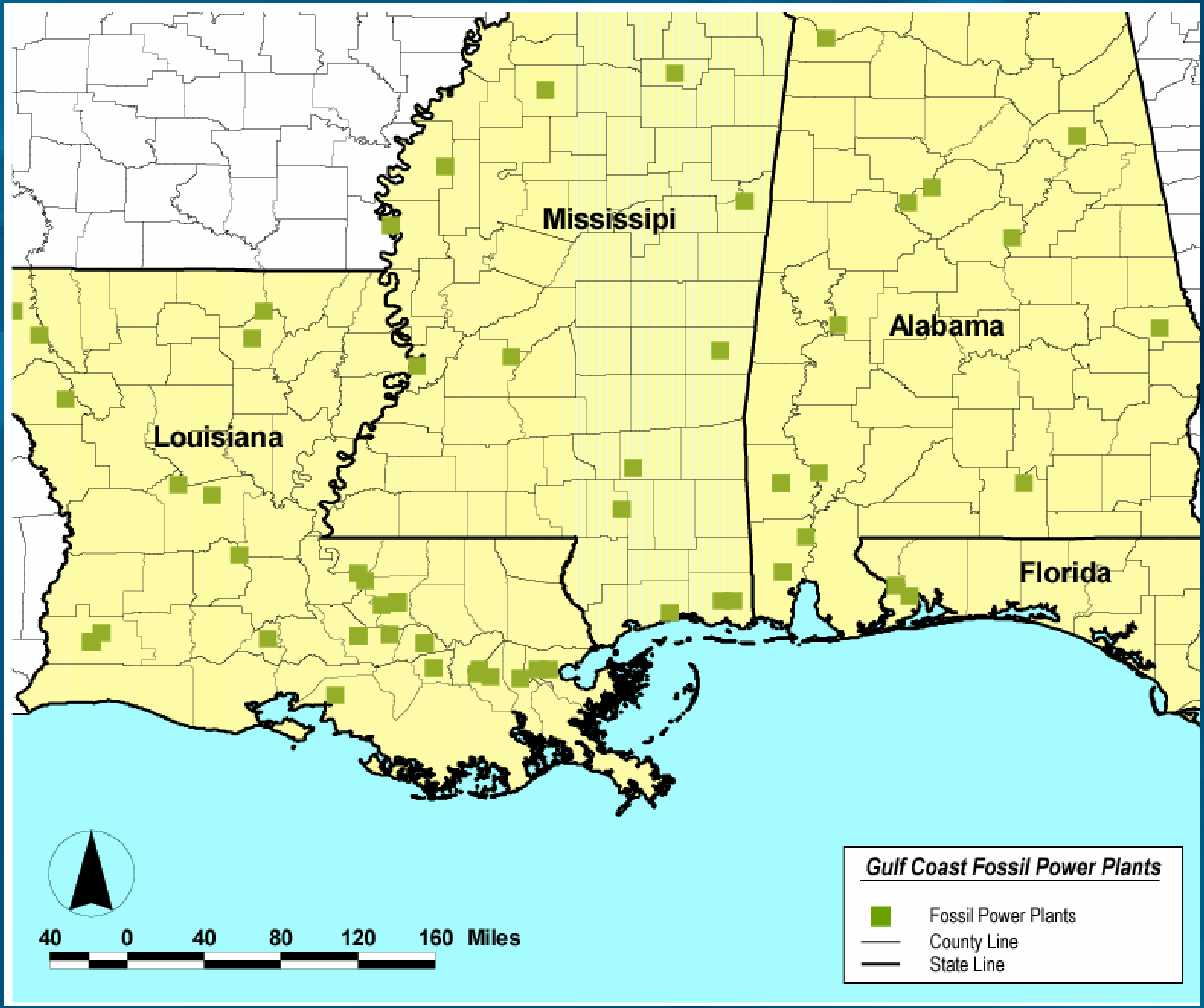
Saline Aquifer Test Center Project
Sources of CO_2

- **A large number of industrial sources of CO_2 emissions exist in the SECARB region. Of particular note are four high CO_2 concentration sources:**
  - Hydrogen plants at oil refineries (e.g., the ChevronTexaco refinery at Pascagoula, MS has a 238 MMcfd hydrogen plan emitting about 100 MMcfd (2 MMt/yr of CO_2),
  - Ammonia plants,
  - Gas processing plans, and
  - Ethylene/ethylene oxide plants
- **In addition, a significant number of major coal-fired power plants exist in the area.**
- **Denbury Resources operates a CO_2 pipeline from Jackson Dome to oil fields in Mississippi and Louisiana.**

High Concentration CO_2 Sources and Pipelines



Major Electric Power Plants – SECARB Region



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