An Overview of Current Carbon Dioxide Capture and Geologic Storage (Sequestration) Activities in Texas

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Gulf Coast Carbon Center
Bureau of Economic Geology
The University of Texas at Austin

BUT IT IS ALSO ABOUT THE ENVIRONMENT…

Must satisfy energy demand within environmental constraints:
What do people care about most?

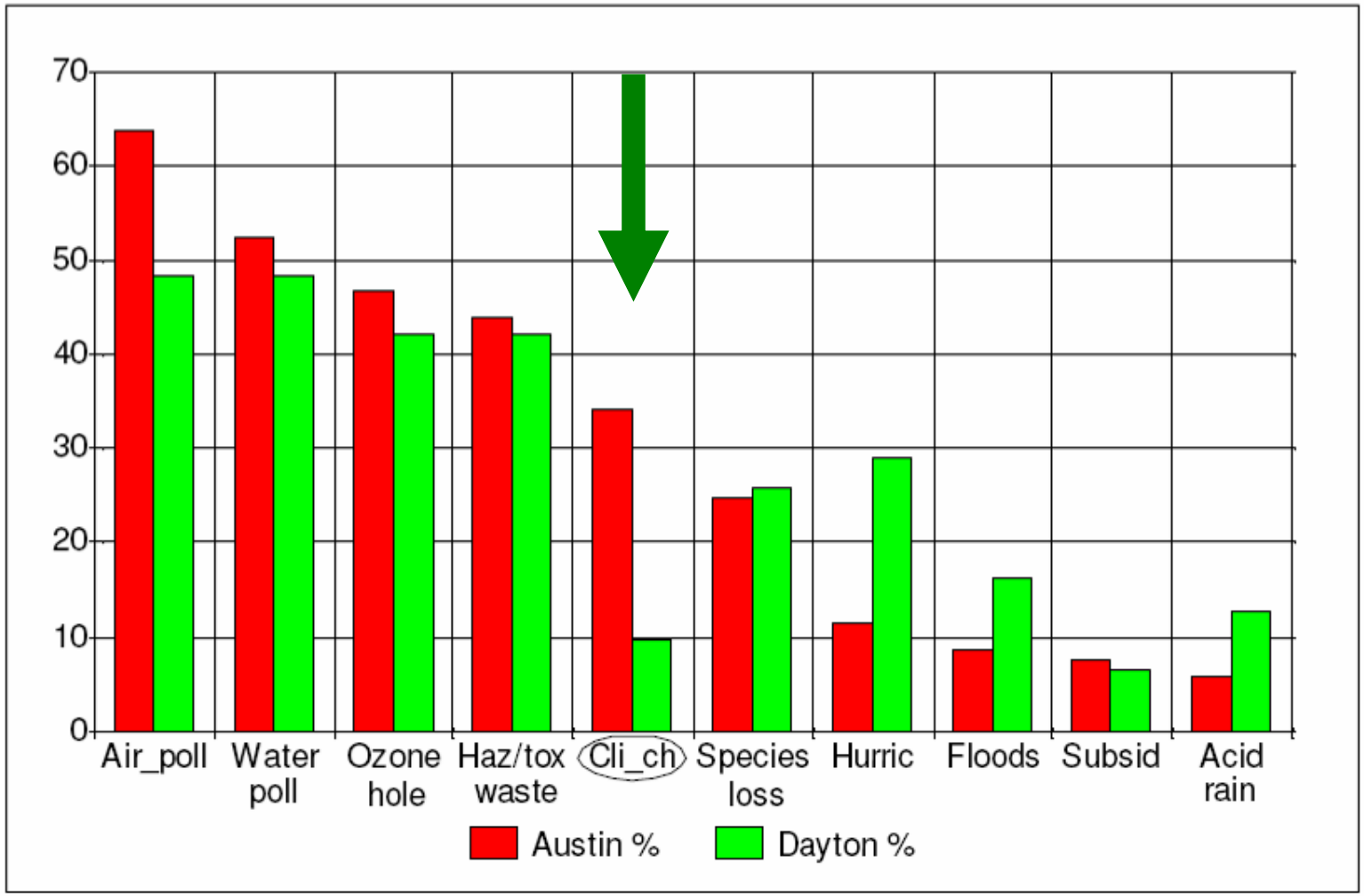
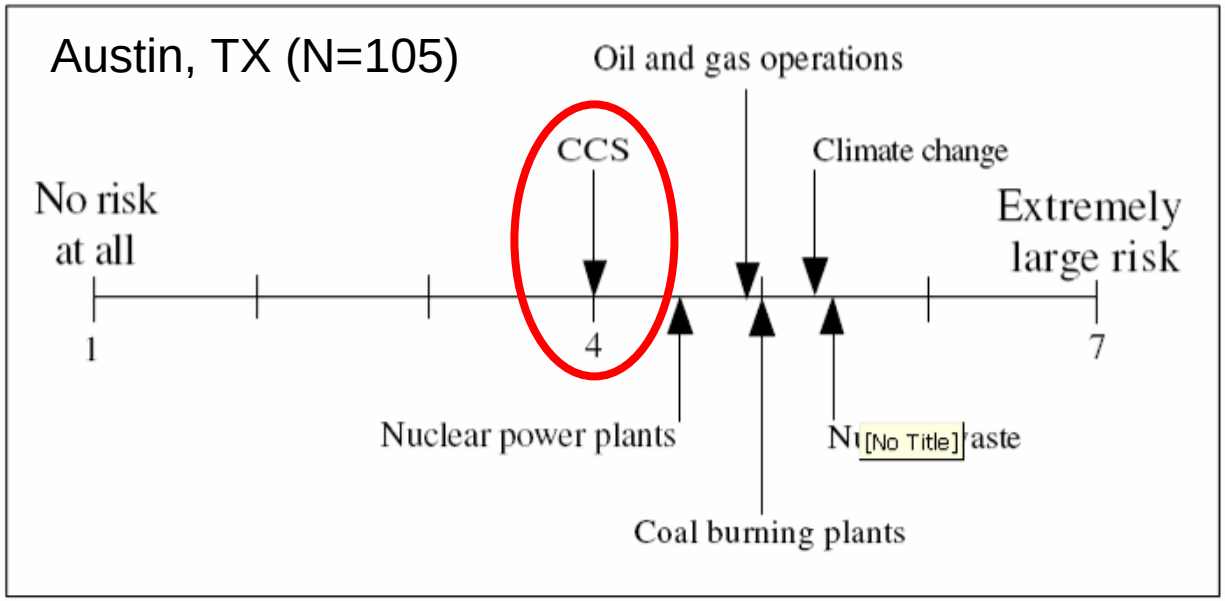
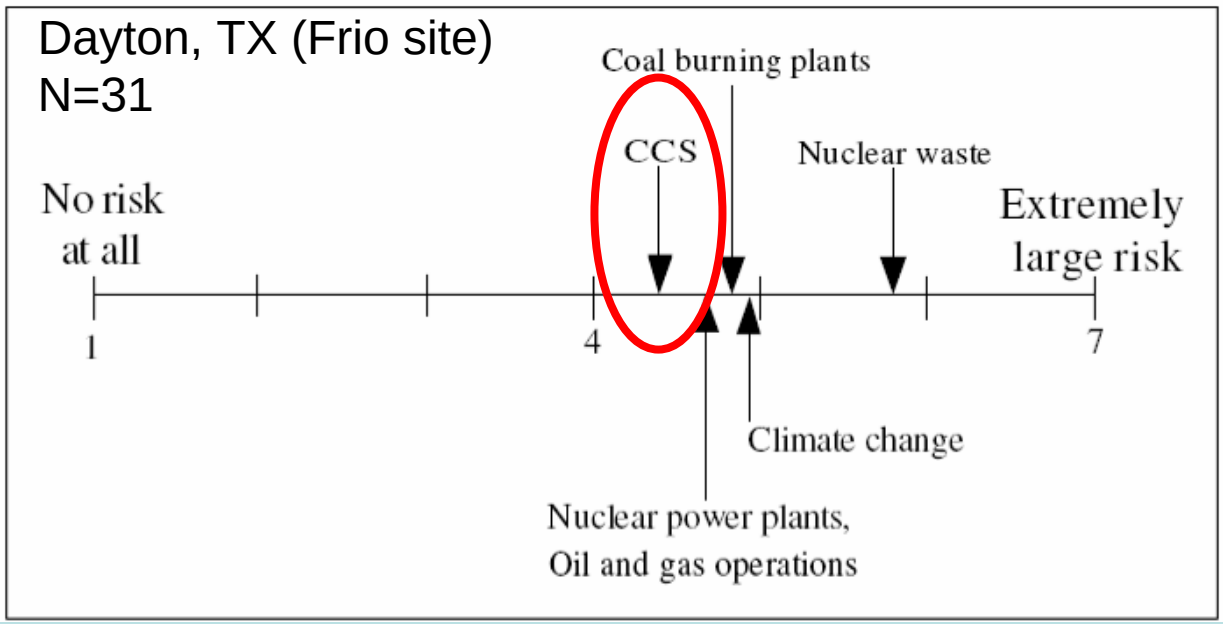


Figure 5.1. What are your top three environmental concerns? (Q2b)



Average perceived health risks

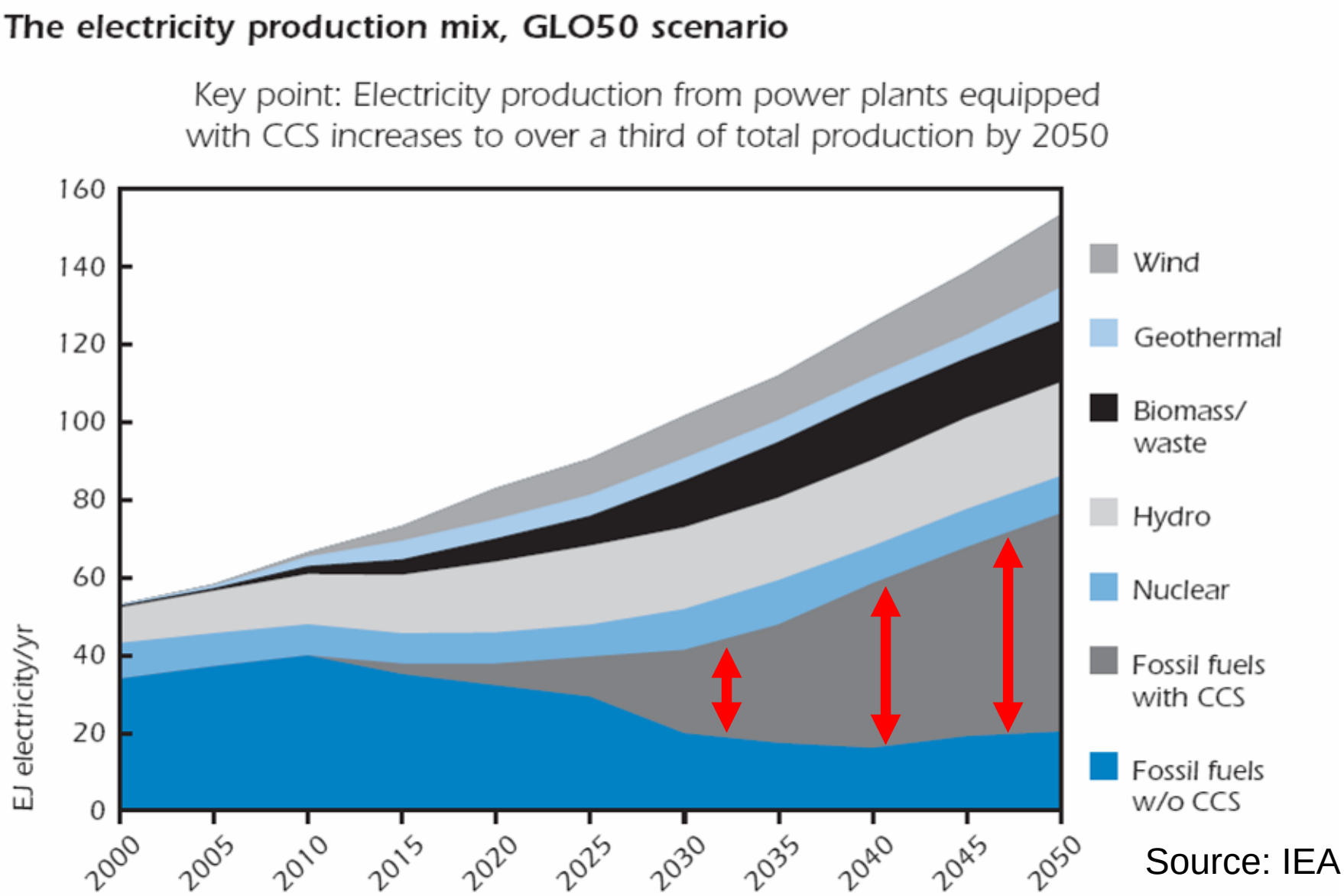


Rebekah Lee
Undergraduate Thesis
Oxford University, UK

BEG GCCC Survey

AND IT IS ALSO ABOUT ECONOMICS…

Where will the electricity come from?



Source: IEA

Decarbonized Energy Benefits

Environment:

Atmospheric benefits of capturing and storing CO2

Energy:

CO2 – EOR (Enhanced oil recovery), EGR

Economy:

Jobs, taxes, infrastructure, development, etc.

Current level of activity is intense

- **Legislative (110th Congress)**
  - 100+ Congressional actions addressing aspects of global warming, climate change, carbon sequestration, etc.
  - Lieberman-Warner Proposal (Cap & Trade= 19% by 2020, 20% by 2050)
    - first comprehensive climate change measure to clear a congressional panel
  - Bingaman – CCS Bill
    - ***"The topic of carbon capture and storage is central to the future of coal in the United States and our future energy policy"***
  - Salazar / Bunning: National CO2 Storage Capacity Assessment Act
  - Dingell / Boucher White Paper (Cap & Trade)
- **Regulatory / Legal**
  - EPA: *Mass. Vs. EPA*, Rulemaking for CSS (2008)
  - IOGCC; RGGI
  - *"Kansas Permit Denial Prompts Legal Fight Echoing Nationwide CO2 Debate"*
- **Industrial/Markets**
  - Trading: European and Chicago Climate Exchange
    - The carbon market grew in value to an estimated $30 billion in 2006
  - FutureGen & FutureGen-like projects
  - TxCCSA
- **Research**
  - DOE / NETL Regional Partnerships
    - BEG – Gulf Coast Carbon Center

TEXAS AND GREENHOUSE GASES

Where Texas ranks nationally in carbon dioxide emissions from fossil-fuel burning, in millions of tons per year:

1. Texas	723.2	
2. California	422.3	711
3. Pennsylvania	288.7	
4. Ohio	278.1	
5. Florida	263.2	
6. Indiana	253.8	
7. Illinois	250.3	
8. New York	233.1	
9. Michigan	212.4	
10. Louisiana	182.2	

Where Texas ranks worldwide:

1. United States	6,517.0	11,706
2. China	5,188.8	
3. Russia	1,857.2	7,984
4. Japan	1,391.2	
5. India	1,227.7	
6. Germany	950.4	
7. Texas	723.2	
8. Canada	648.1	
9. United Kingdom	639.0	
10. South Korea	547.6	

Figures are the most recent available: 2001 for U.S. states, 2004 for countries. Texas' worldwide rank does not change if 2001 figures for countries are used.

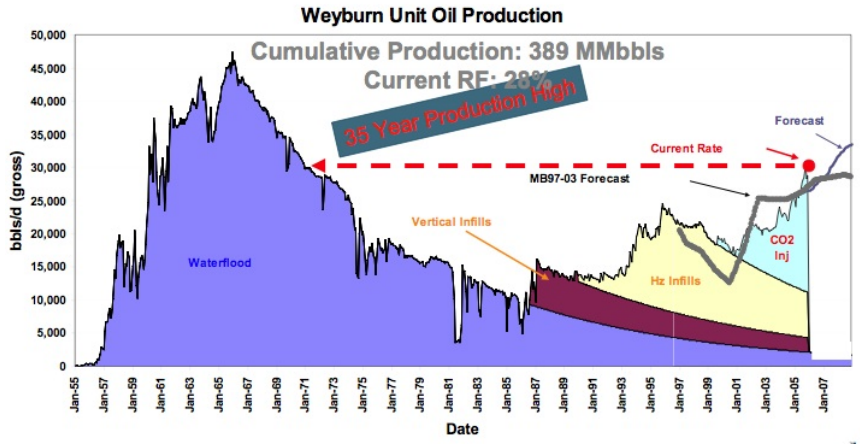
SOURCE: U.S. Energy Information Administration

Some Major Geologic Projects Underway

(1 Million TPY CO_2 , ~ 100 MW Coal Power Plant)

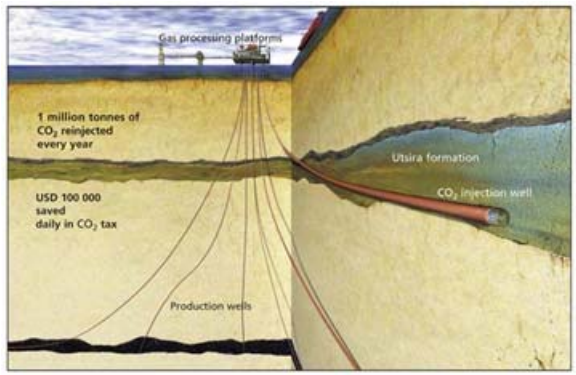
Weyburn CO_2 EOR Project

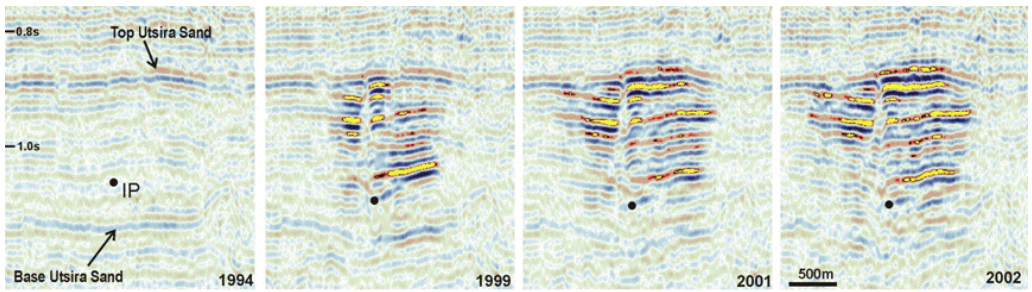
- Pan Canadian Resources / Encana
- 200-mile CO_2 pipeline from Dakota Gasification Plant
- 130M barrels oil over 20-year project



Sleipner North Sea Project

- Statoil
- Currently monitoring CO_2 migration
- MCS imagine a success





Also: In Salah, Algeria (BP)
Gorgon, Australia (Chevron; 100 Mt)

Seven regional partnerships

Partnership	Partnership Lead	States Represented
Midwest Regional Carbon Sequestration Partnership	Battelle Memorial Institute	IA, KY, MI, MD, OH, PA, WV
An Assessment of Geological Carbon Sequestration Options in the Illinois Basin	The Board of Trustees of the University of Illinois, Illinois State Geological Survey	IL, IN, KY
Southeast Regional Carbon Sequestration Partnership	Southern States Energy Board	AL, AR, FL, GA, LA, MS, NC, SC, TN, TX, VA
Southwest Regional Partnership for Carbon Sequestration	New Mexico Institute of Mining and Technology	AZ, CO, KS, NE, NM, OK, TX, UT, WY
West Coast Regional Carbon Sequestration Partnership	State of California, California Energy Commission	AK, AZ, CA, NV, OR, WA
Big Sky Regional Carbon Sequestration Partnership	Montana State University	ID, MT, SD, WY
Plains CO2 Reduction Partnership	University North Dakota - Energy & Environmental Research Center	IA, MO, MN, ND, NE, MT, SD, WI, WY

SECARB: Regional Involvement: 100+ Participants

Member States (Executive, Legislative and Regulatory)
Industry and Electric Utilities
Universities and National Laboratories
NGOs and Trade Associations

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

Gulf Coast Carbon Center (GCCC)

Gulf Coast Carbon Center

Mission: ***Global leadership in research and economic implementation of large scale greenhouse gas sequestration.***

Bureau of Economic Geology

NETL National Energy Technology Laboratory

GCCC Team:

Ian Duncan, Susan Hovorka, Tip Meckel, Becky Smyth, J. P. Nicot, Jeff Paine + 4 new post-docs, MA student, URA

Steve Bryant & Gary Rochelle (UT- Chem. Eng.)

Department of Energy, United States of America

Sponsors

bp

Chevron

Schlumberger

Shell

KINDER MORGAN

PRAXAIR

LCRA Energy • Water • Community Services

Austin Energy

Marathon

NRG

Entergy The Power of People

The University of Texas at Austin Jackson School of Geosciences

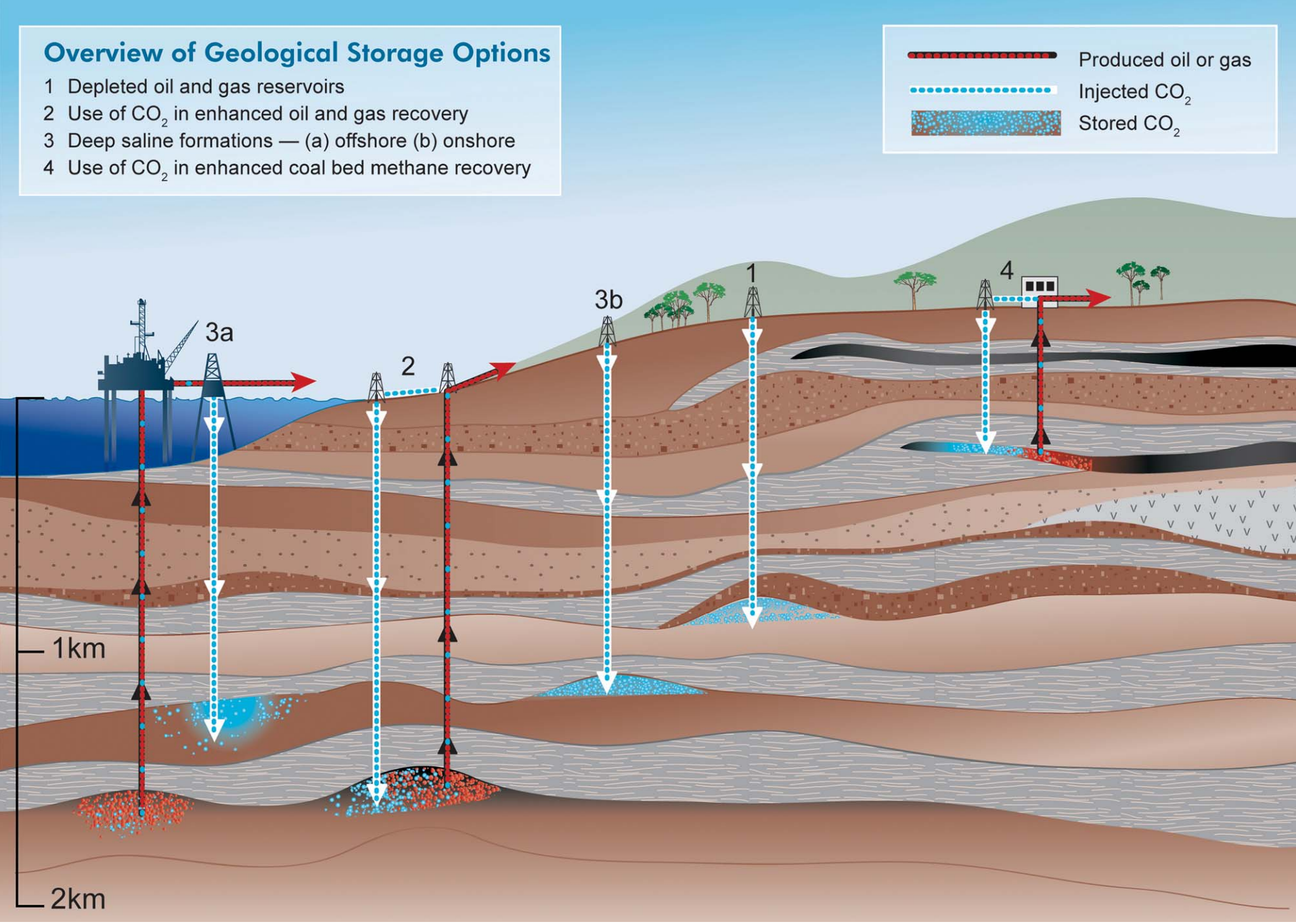
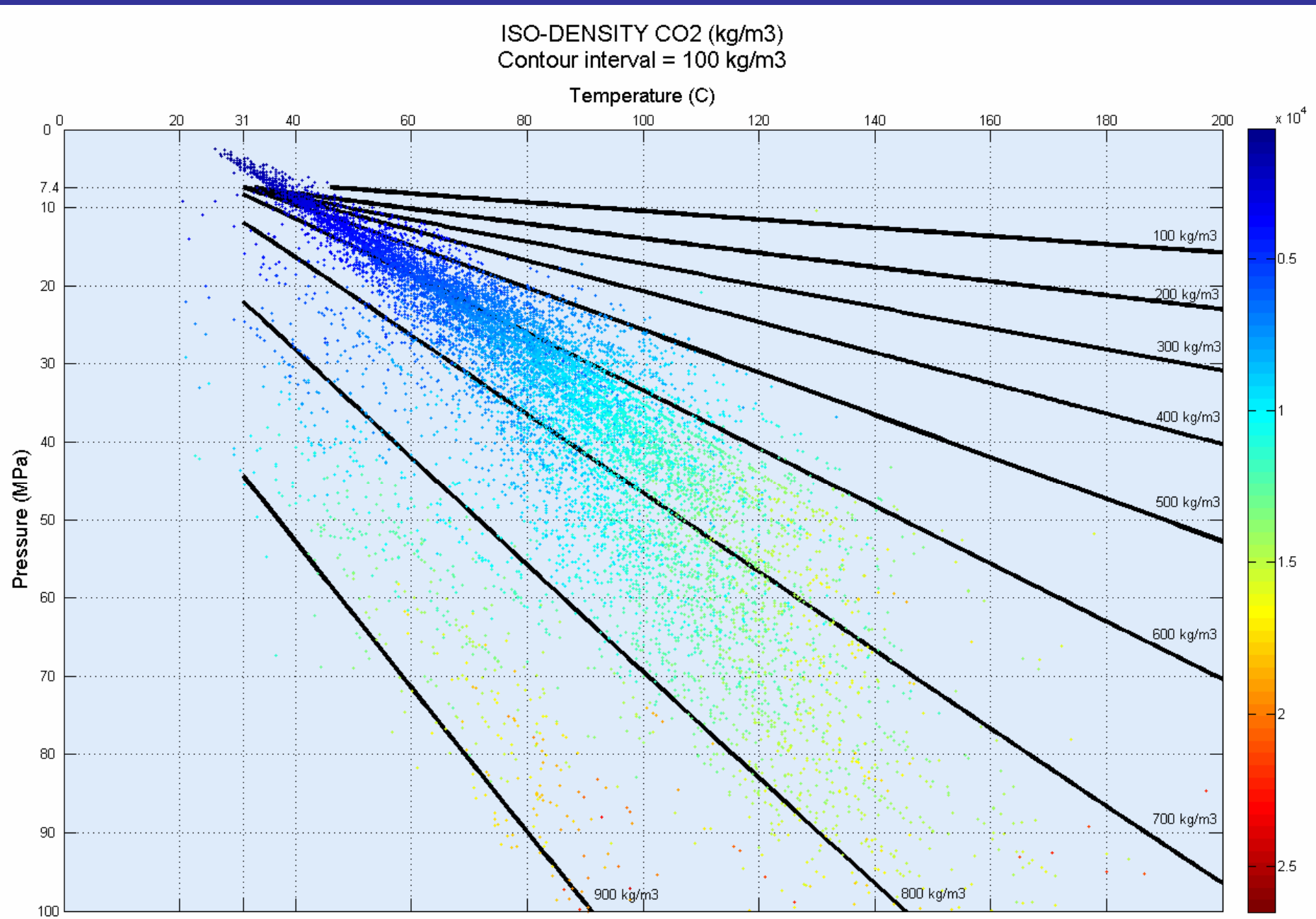


Image from CO2-CRC


ISO-DENSITY CO2 (kg/m3)
Contour interval = 100 kg/m3
Temperature (C)
0
20
31
40
60
80
100
120
140
160
180
200
Pressure (MPa)
0
7.4
10
20
30
40
50
60
70
80
90
100
100 kg/m3
200 kg/m3
300 kg/m3
400 kg/m3
500 kg/m3
600 kg/m3
700 kg/m3
800 kg/m3
900 kg/m3
x 10^4
0.5
1
1.5
2
2.5

What are subsurface prospects for storing CO2?

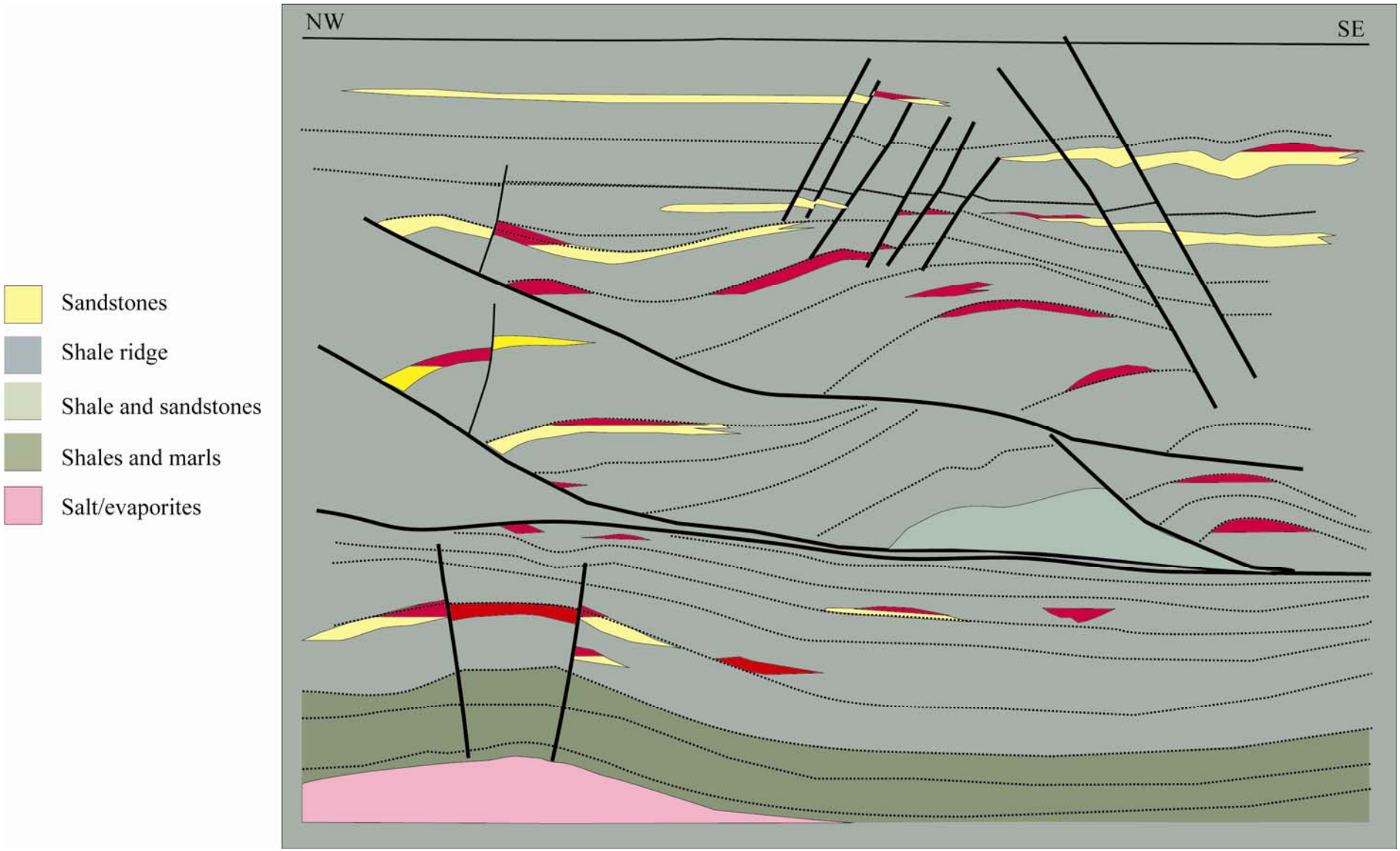


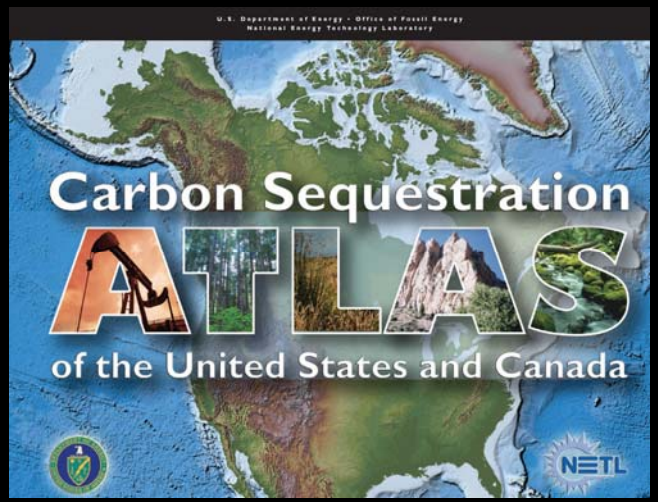
Image courtesy of Angela McDonnell, BEG

State	Number of Fields		Cumulative Recovery		Conventional CO_2 Storage Capacity		Technically Recoverable Oil from CO_2-EOR	Additional CO_2 Storage Capacity**	
	Total	Assessed	Oil (Million Bbls)	Gas (Bcf)	(Million Metric Tons)	(Bcf)	(Million Bbls)	(Million Metric Tons)	(Bcf)
Alabama	133	63	622	1,856	344	6,504	410	43	820
Florida	23	8	556	0	109	2,061	180	19	360
Mississippi	110	101	1,346	5,300	399	7,549	850	90	1,700
Louisiana	964	331	11,847	117,697	6,781	128,153	5,480	580	10,960
Arkansas	42	42	1,394	1,415	250	4,728	340	36	680
Virginia	49	49	–	89	10	180	–	–	–
Tennessee	213	213	–	–	–	–	–	–	–
Federal Offshore	1,337	1,001	15,843	176,466	17,754	335,550	5890*	623	11,780
Texas	678	678	12,510	29,373	4,005	75,695	N/A	N/A	N/A
TOTAL	**3,549**	**2,486**	**44,118**	**332,196**	**29,652**	**560,420**	**13,150**	**1,392**	**26,300**

An average point source can be 1-10 million tons/year

TX: 732+ Mt/yr total

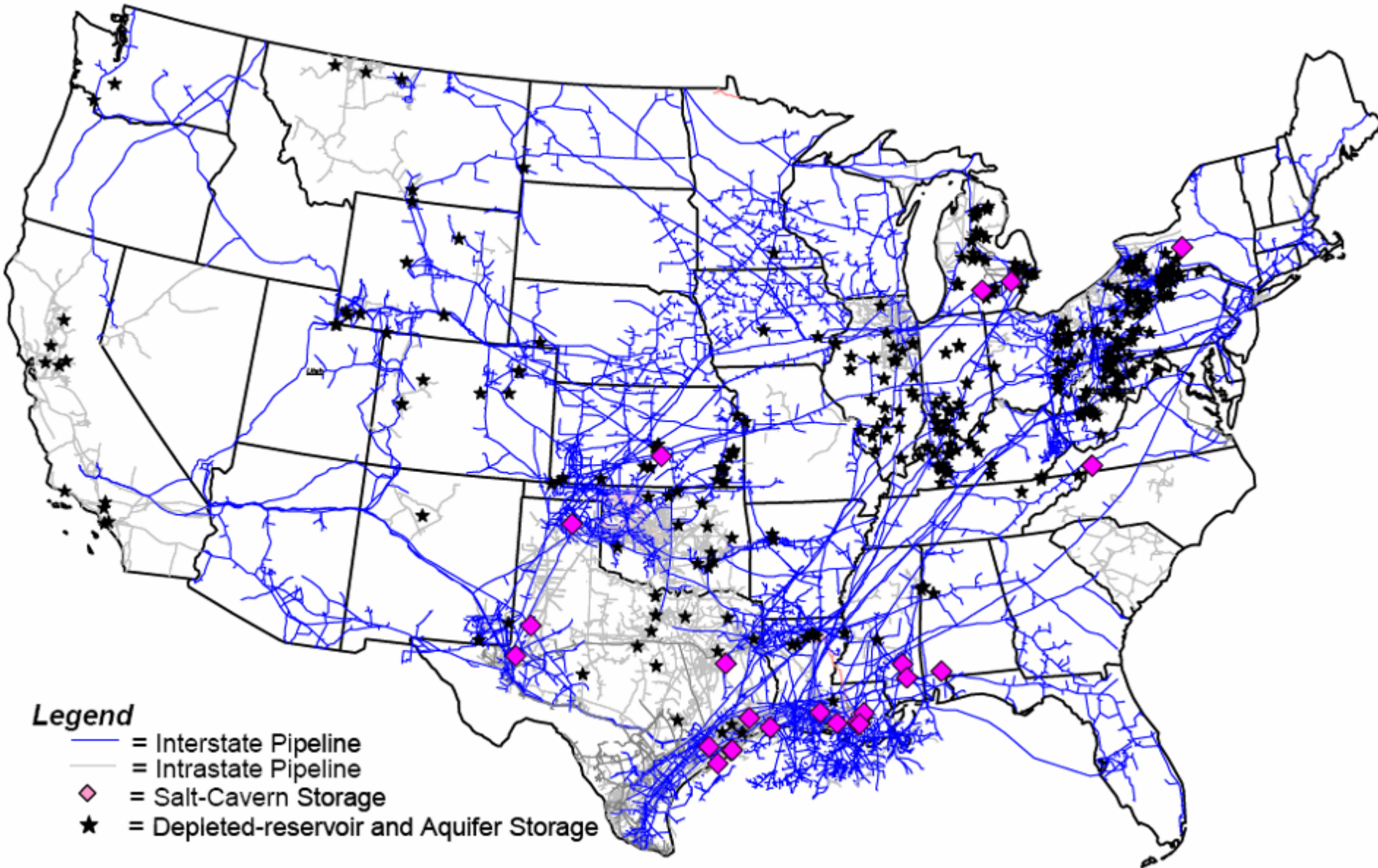
100's of years of potential storage



Saline Formations	CO_2 Storage Capacity			
	Billion Cubic Feet (Bcf)		Million Metric Tons	
	High Estimate P(15)	Low Estimate P(85)	High Estimate P(15)	Low Estimate P(85)
Gulf Coast Basins	13,419,989	3,356,017	710,264	177,567
Tuscaloosa Group	813,456	203,364	43,040	10,760
Woodbine and Paluxy Formations	962,633	240,654	50,933	12,733
Pottsville Formation	210,414	52,599	11,133	2,783
Mt. Simon Sandstone	94,500	23,625	5,000	1,250
Potomac Group	88,376	222,094	47,004	11,751
South Carolina-Georgia Basins	597,070	149,272	31,591	7,898
Cedar Keys, Lawson Formations	2,098,694	524,683	111,042	27,761
Offshore Atlantic (Unit 120)	6,732,936	1,683,234	356,240	89,060
Offshore Atlantic (Unit 90)	586,656	146,664	31,040	7,760
Total	25,604,724	6,602,206	1,397,287	349,323

Current CO_2 – EOR Infrastructure

Underground Natural Gas Storage: Facilities and Transportation Grid



EIA, Office of Oil and Gas

Oil and Natural Gas Production in the United States

(Derived from Mast, et al, 1998)

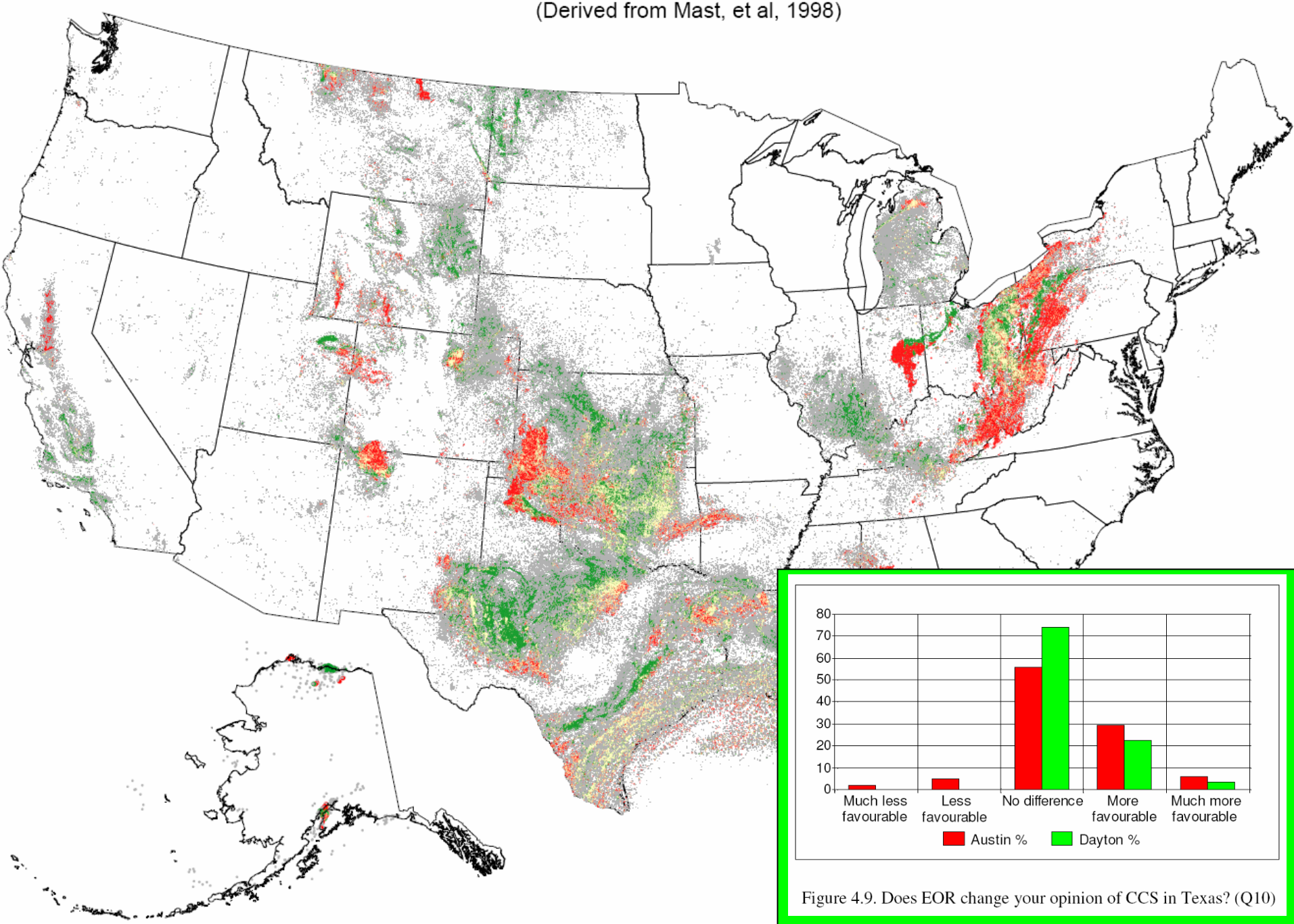
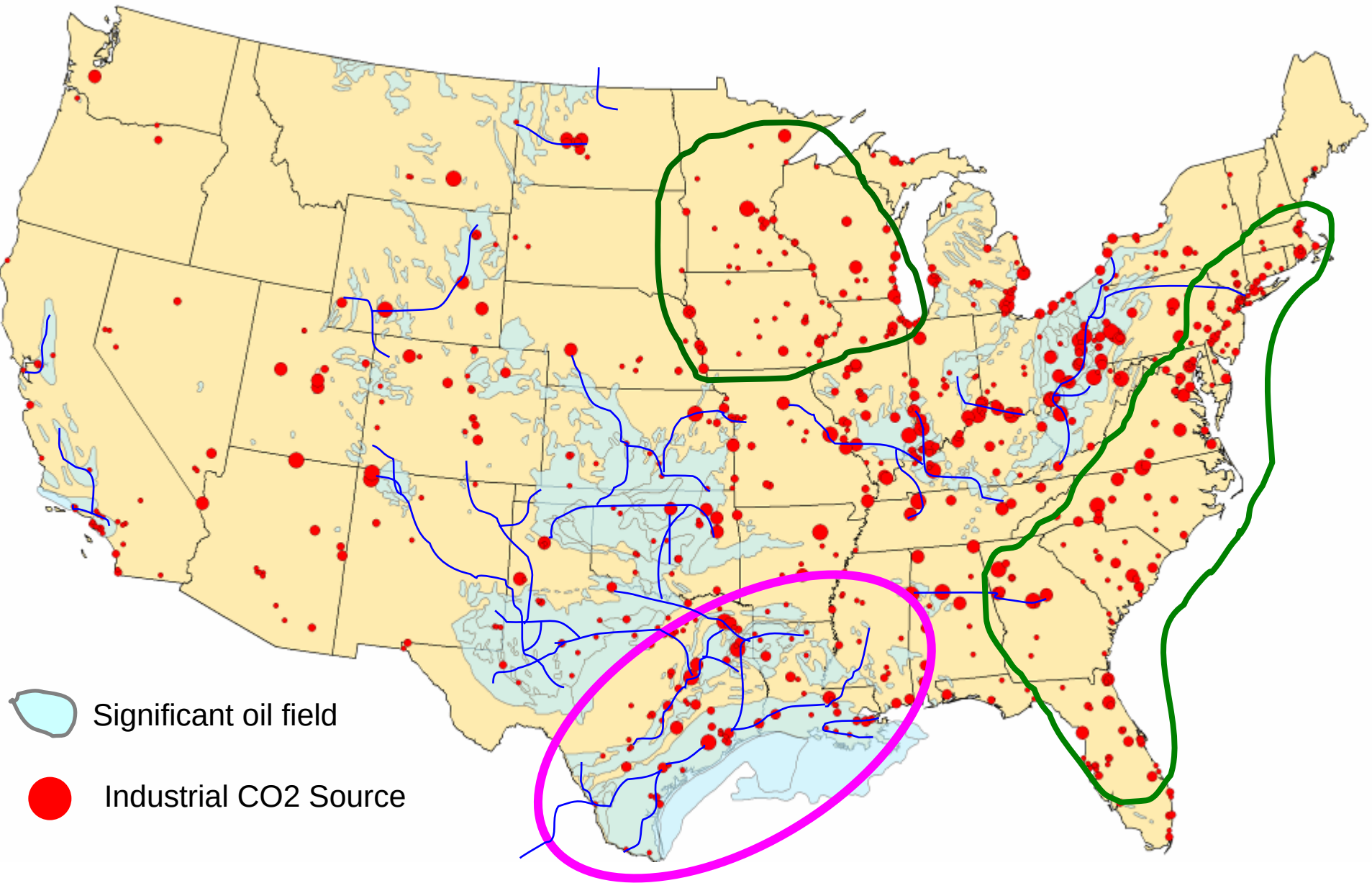
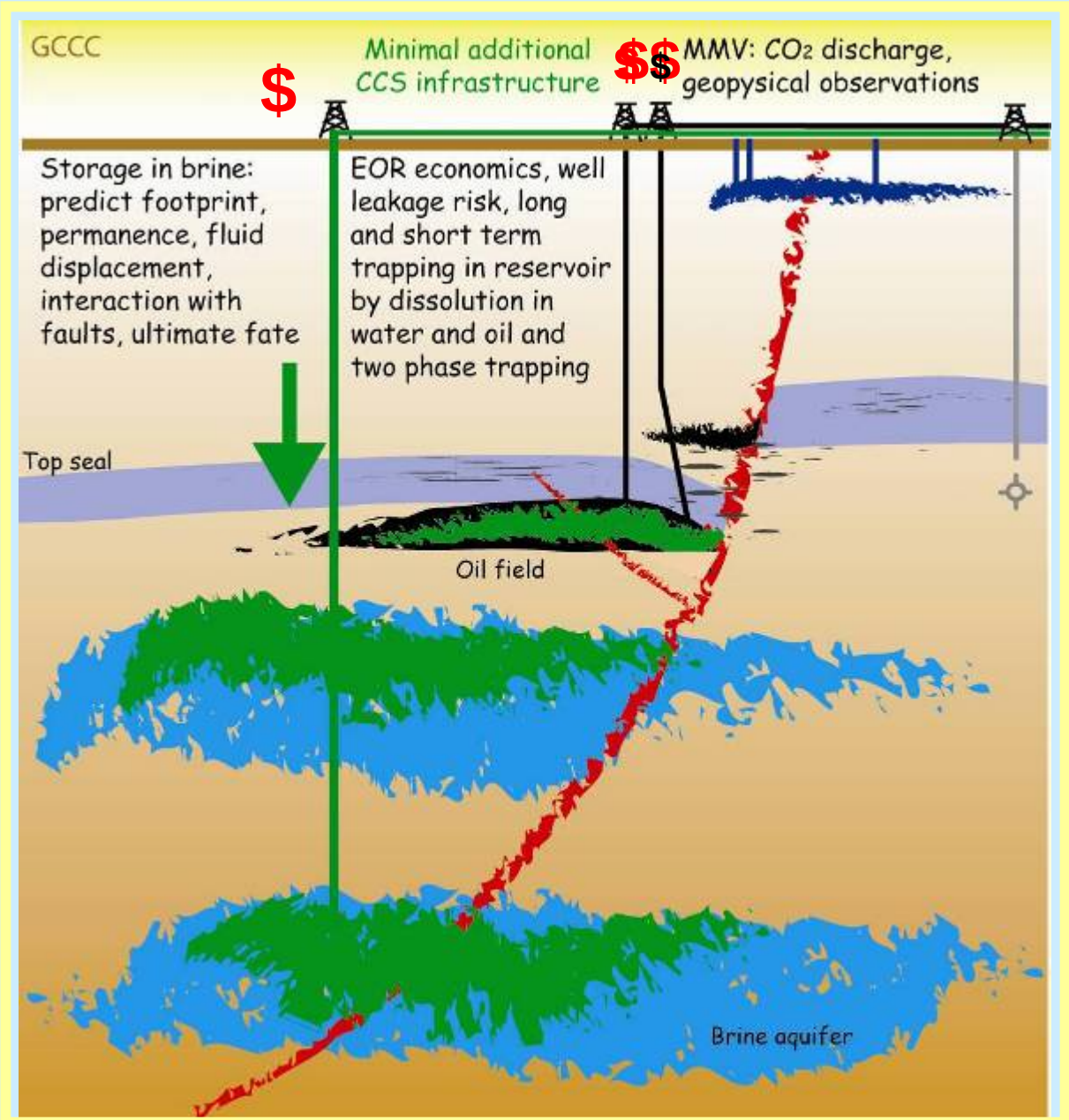


Figure 4.9. Does EOR change your opinion of CCS in Texas? (Q10)

Industrial CO2 sources and oil fields with EOR potential



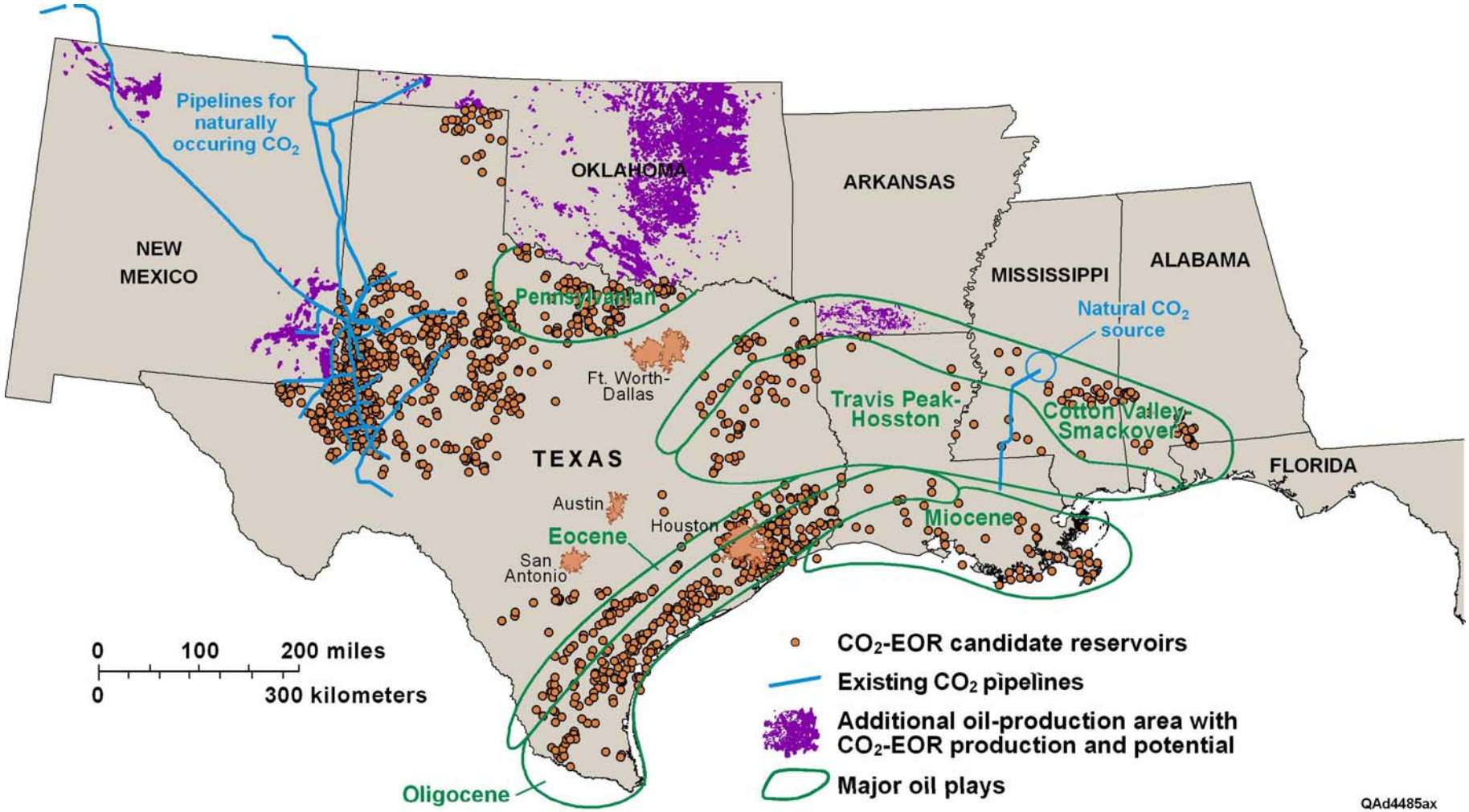
EOR with CO2 can serve as an economic driver in establishing the infrastructure for long-term, larger-volume storage in underlying brine formations.



Gulf Coast Carbon Center

Areas with Miscible CO_2 EOR Potential

Bureau of Economic Geology

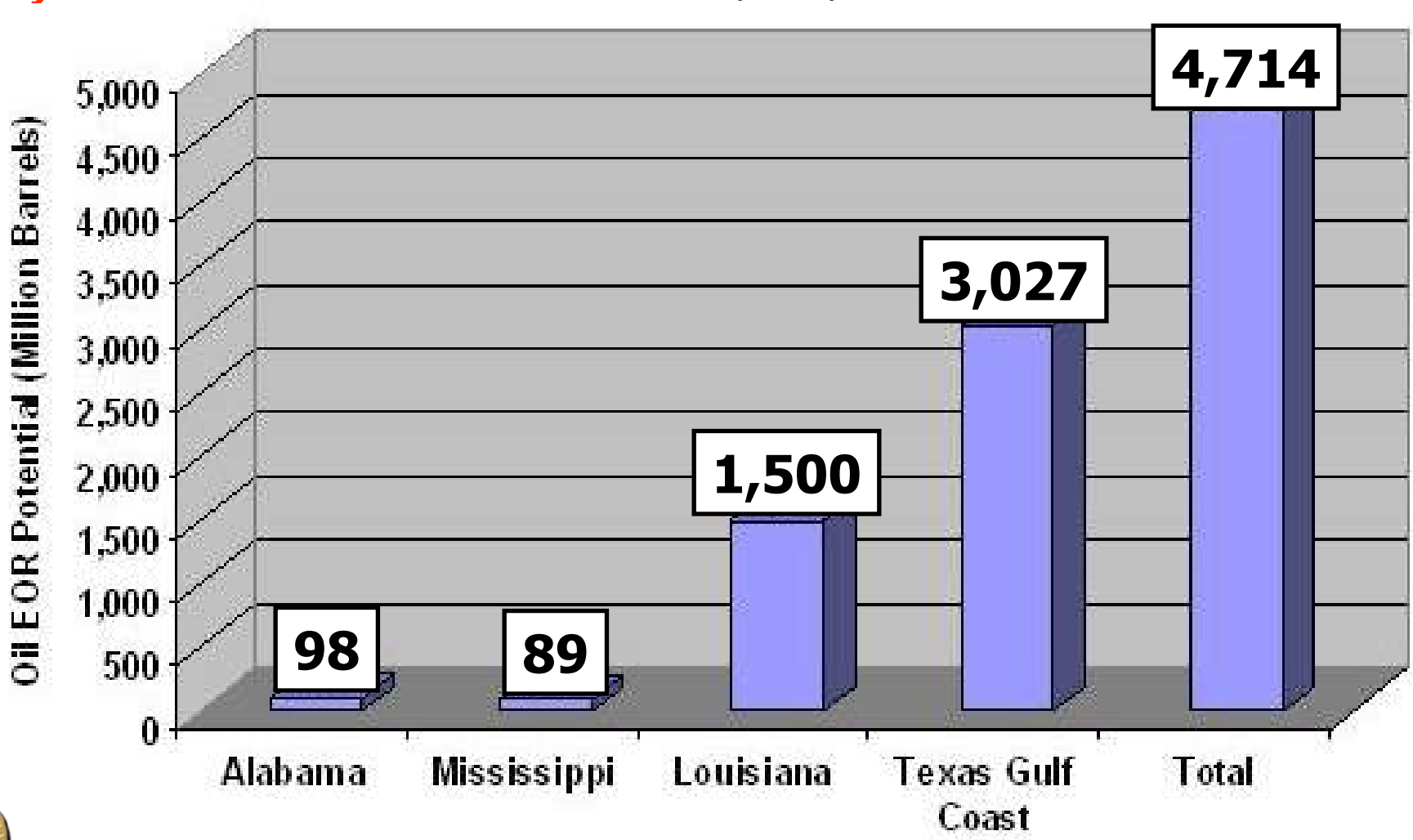


Miscible CO_2 EOR resource potential in the Gulf Coast

Bureau of Economic Geology

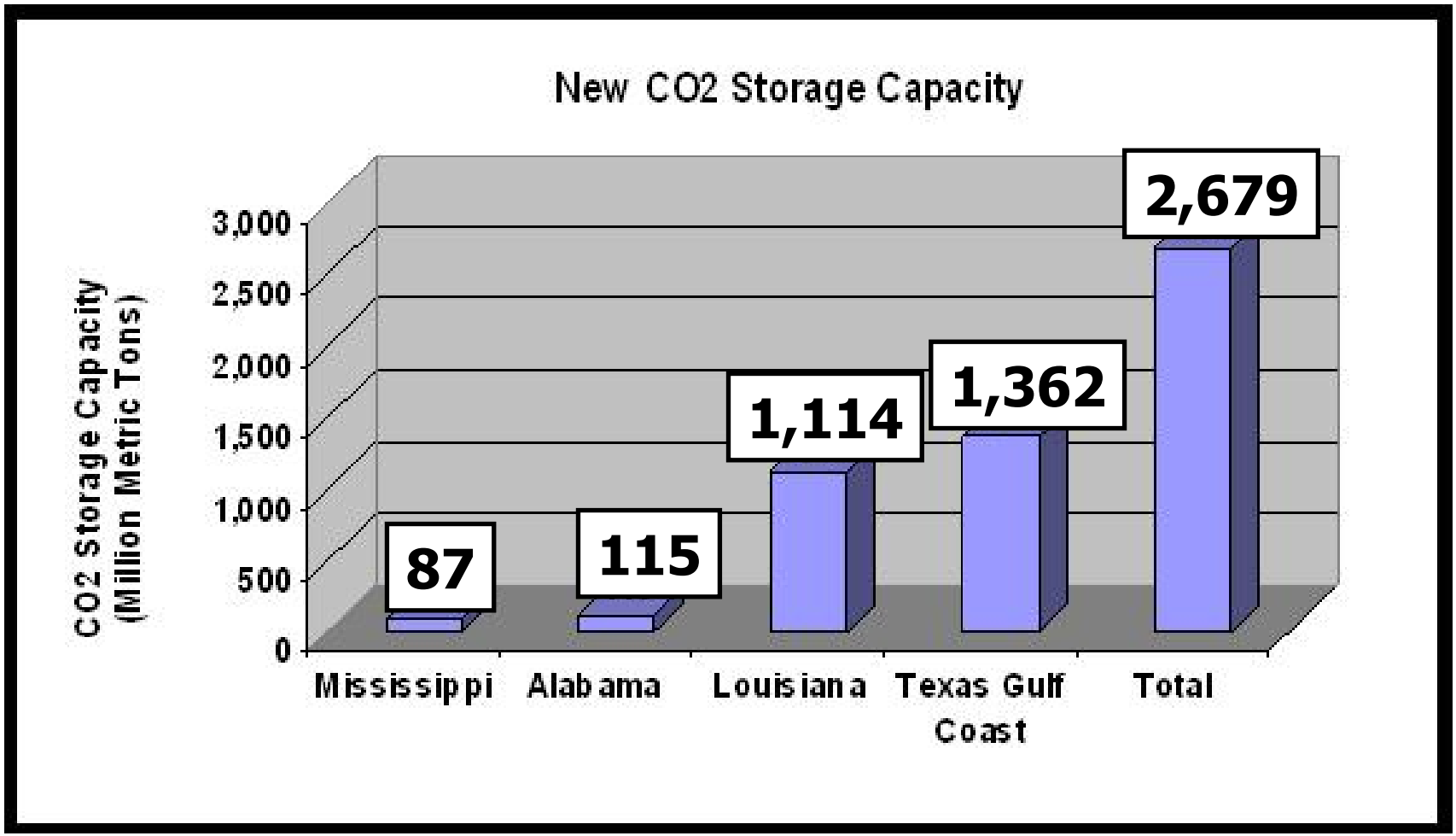
By State

Holtz and others (2005)



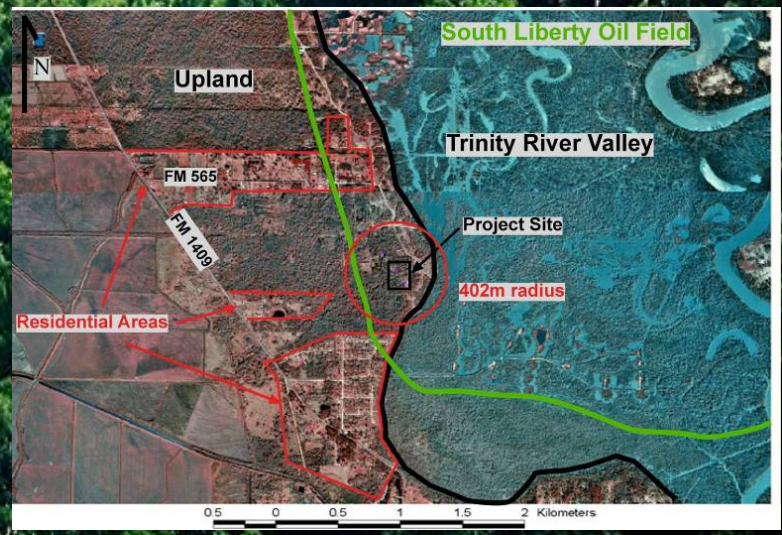
CO_2 Sequestration capacity in miscible oil reservoirs along the Gulf Coast

Bureau of Economic Geology

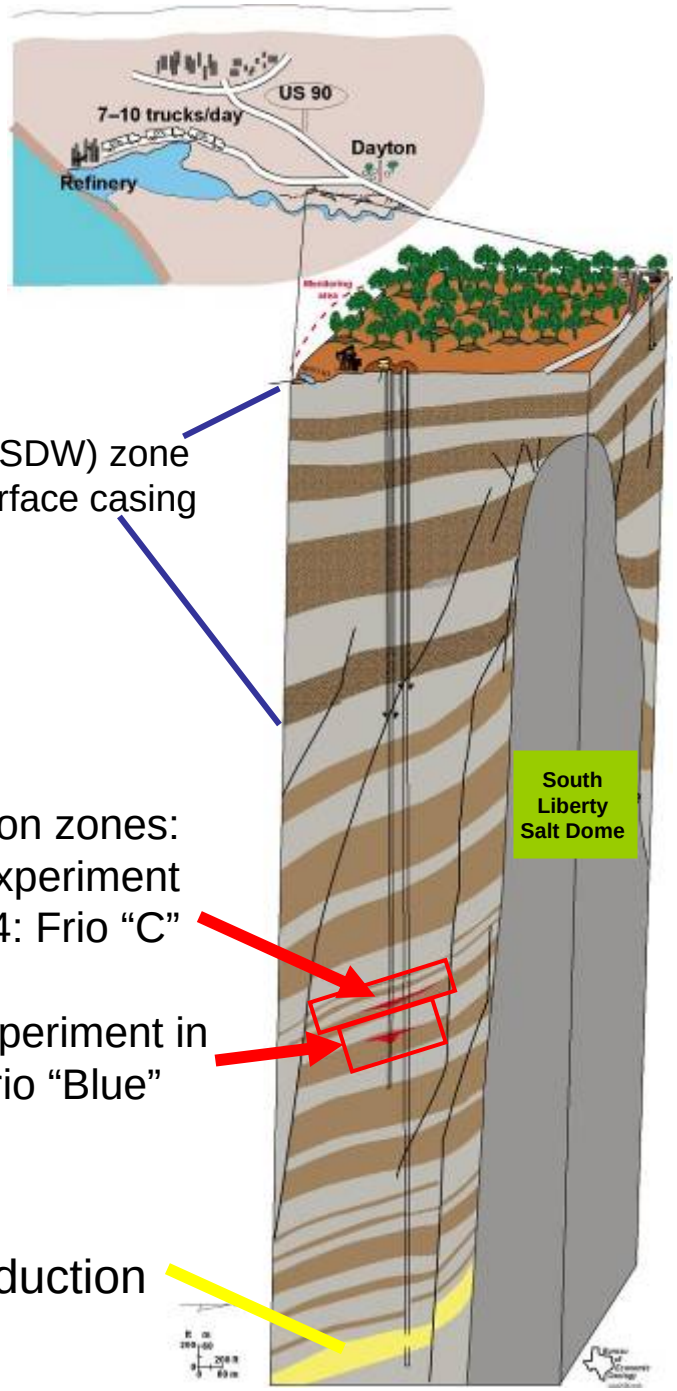


Frio Test

CO_2 Storage in Brine



Gulf Coast Carbon Center

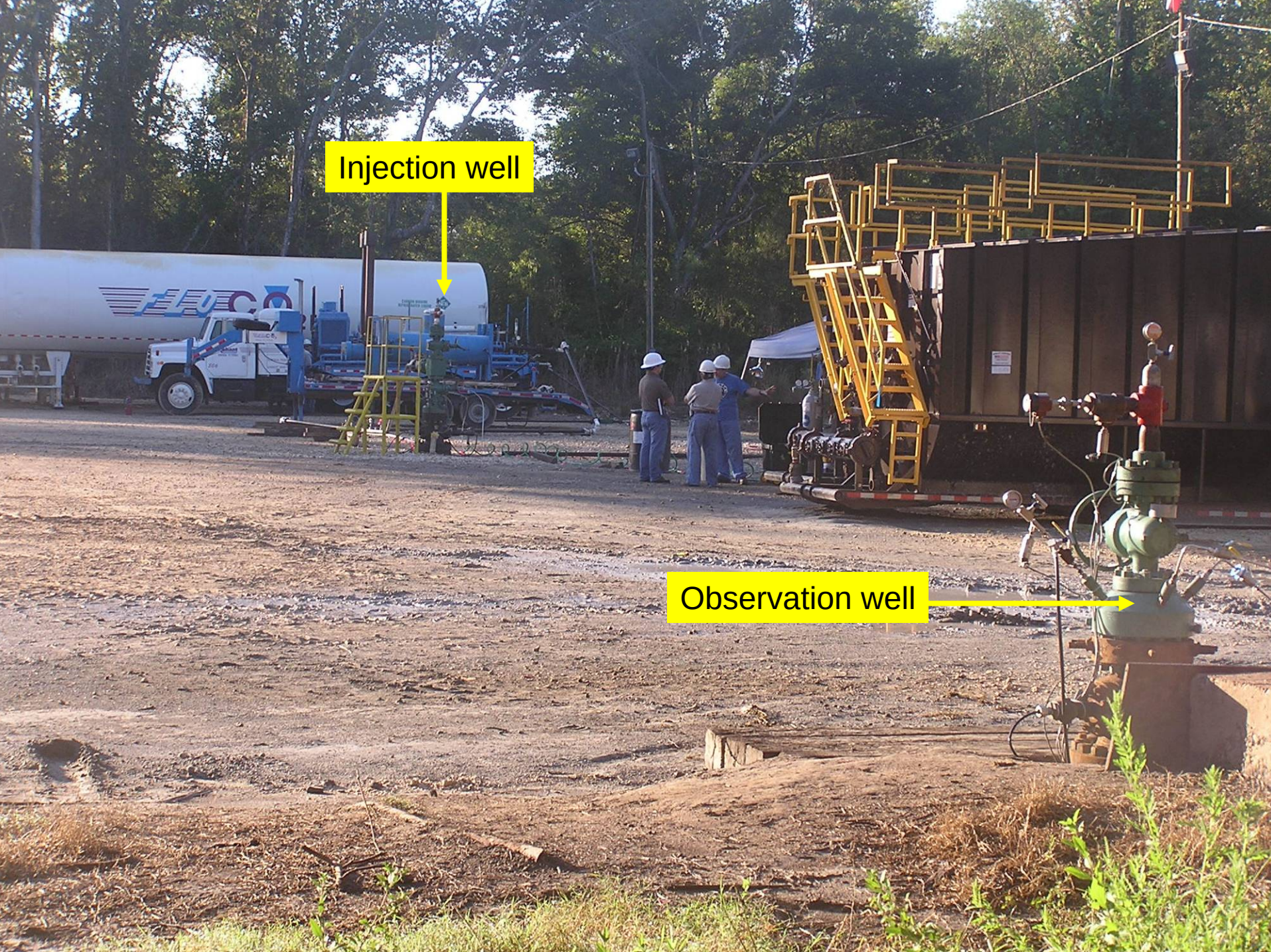


Frio Brine Pilot Site Two Test Intervals

- **Purpose:** demonstrate feasibility and monitoring techniques, evaluate model predictions
- **Setting:** salt dome flank, Frio sandstone, 5,000 ft depth.
- **Scope:** 100’s of tons over weeks
- **Monitoring:** tracers, pressure and temperature, logs, seismic

Frio Pilot Injection: Phase II

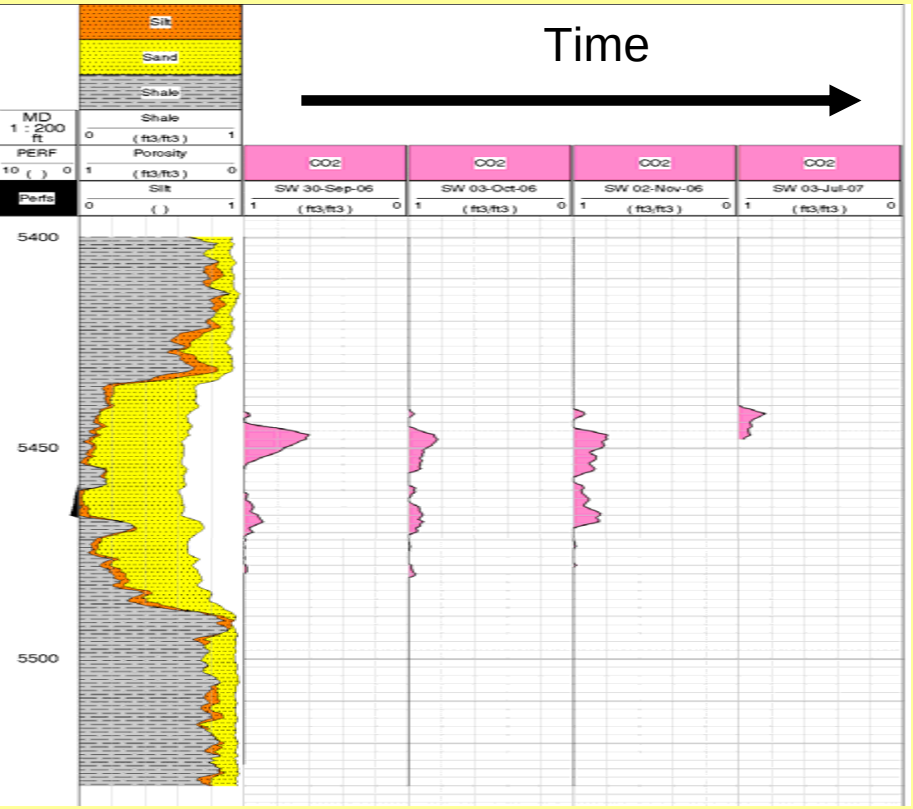
- 500 Tons
- Tracer studies: 4 PFT's and two methanated partitioning tracers (ORNL)
- Geochemical lab (USGS): aqueous tracers and in-line pH and cond.
- On-site Gas Chromatograph (UT-PE)
- U-Tube (LBNL): water & gas @ reservoir conditions in both wells, on-site Mass Spectrometer (SF5, Kr, Xe)
- Cross-well seismic (LBNL) continuous
- Hosting CSIRO-AUS deuterated methane tracer test (Otway)
- Visitors: MIT, Battelle, Taisei Corp (Japan), China Pet. Corp (Taiwan).


Injection well
Observation well

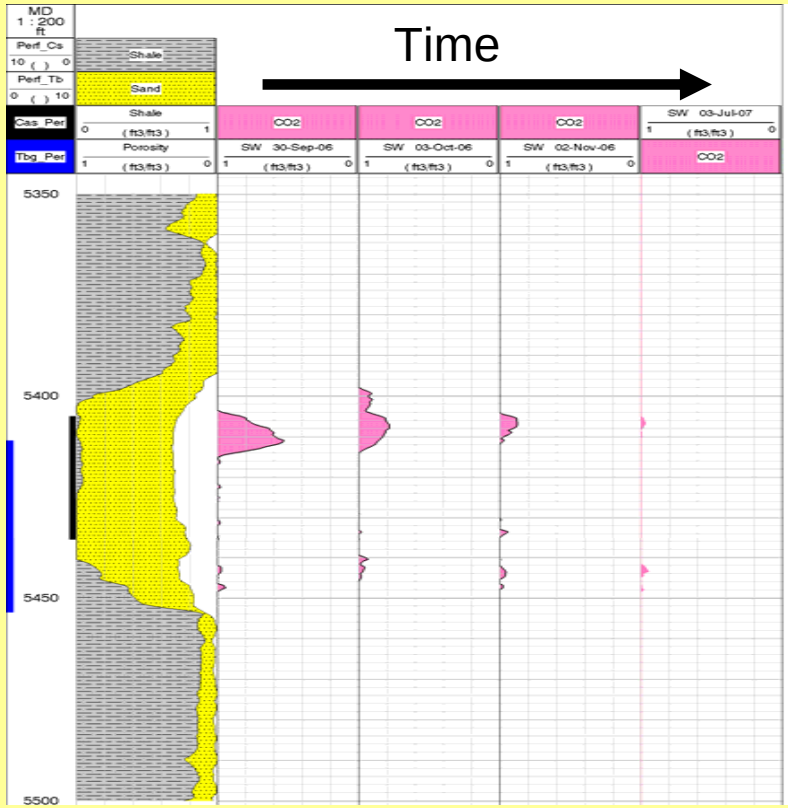
Time-Lapse Changes in Water Saturation(Sw)

CO_2 migrating up-dip leaving dissolved CO_2 in water

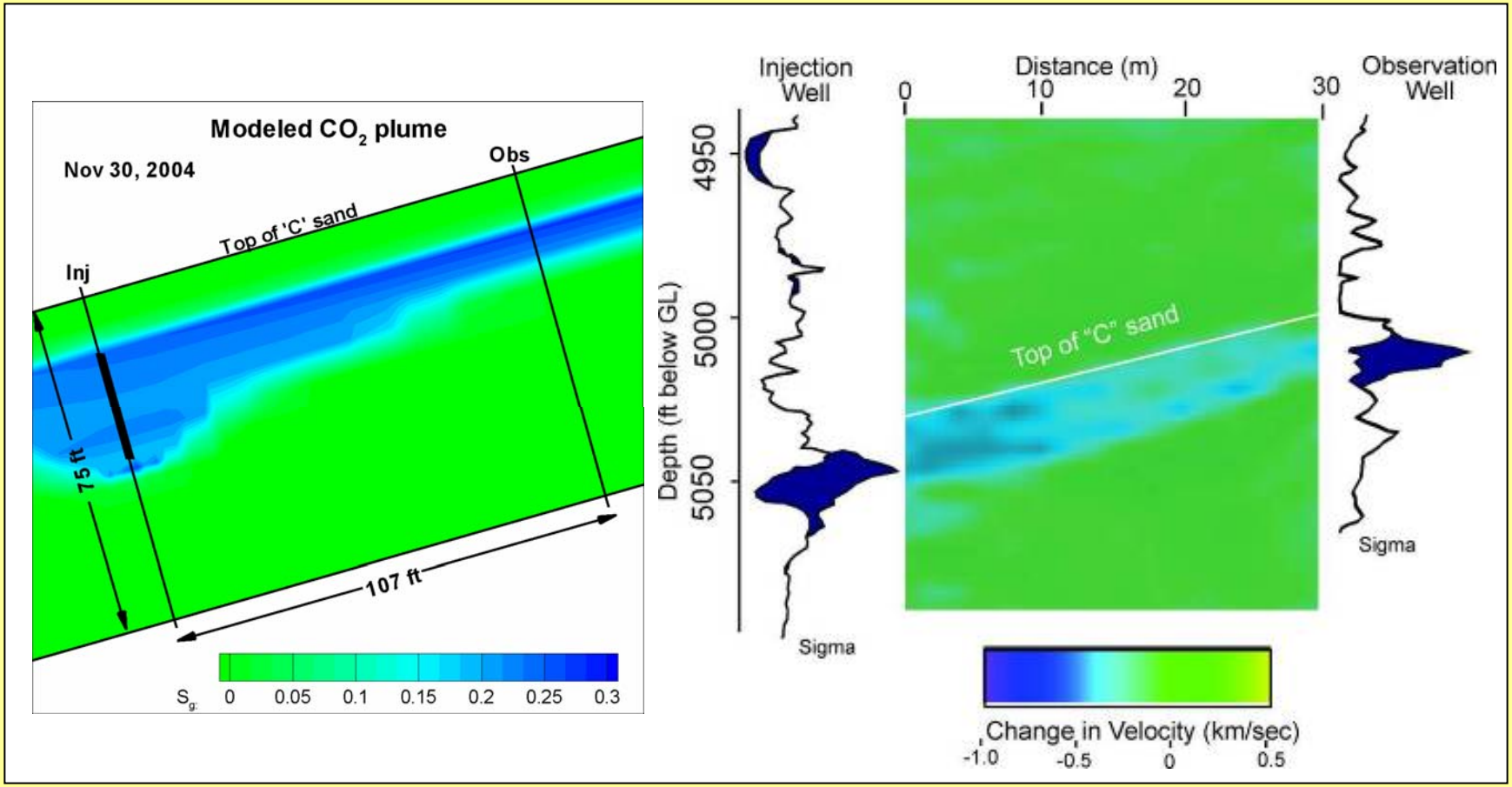
Injection Well



Observation Well



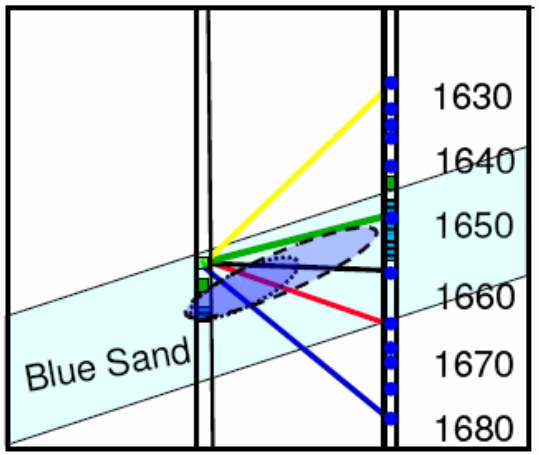
CO_2 Saturation Observed with Cross-well Seismic Tomography vs. Modeled

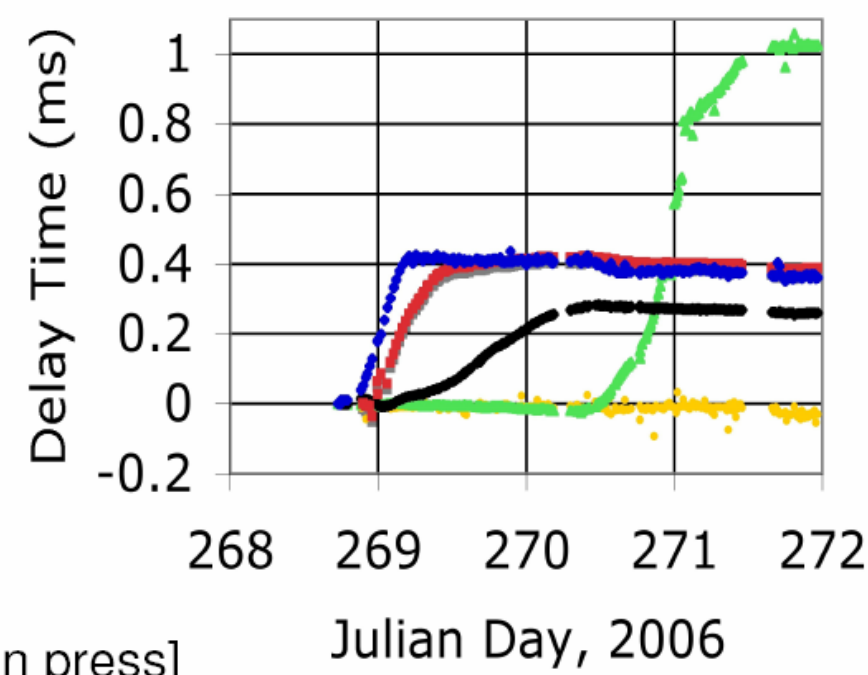


Tom Daley and Christine Doughty, LBNL

Traveltime Response to CO2 Injection

Real time detection using continuous source cross-well seismic

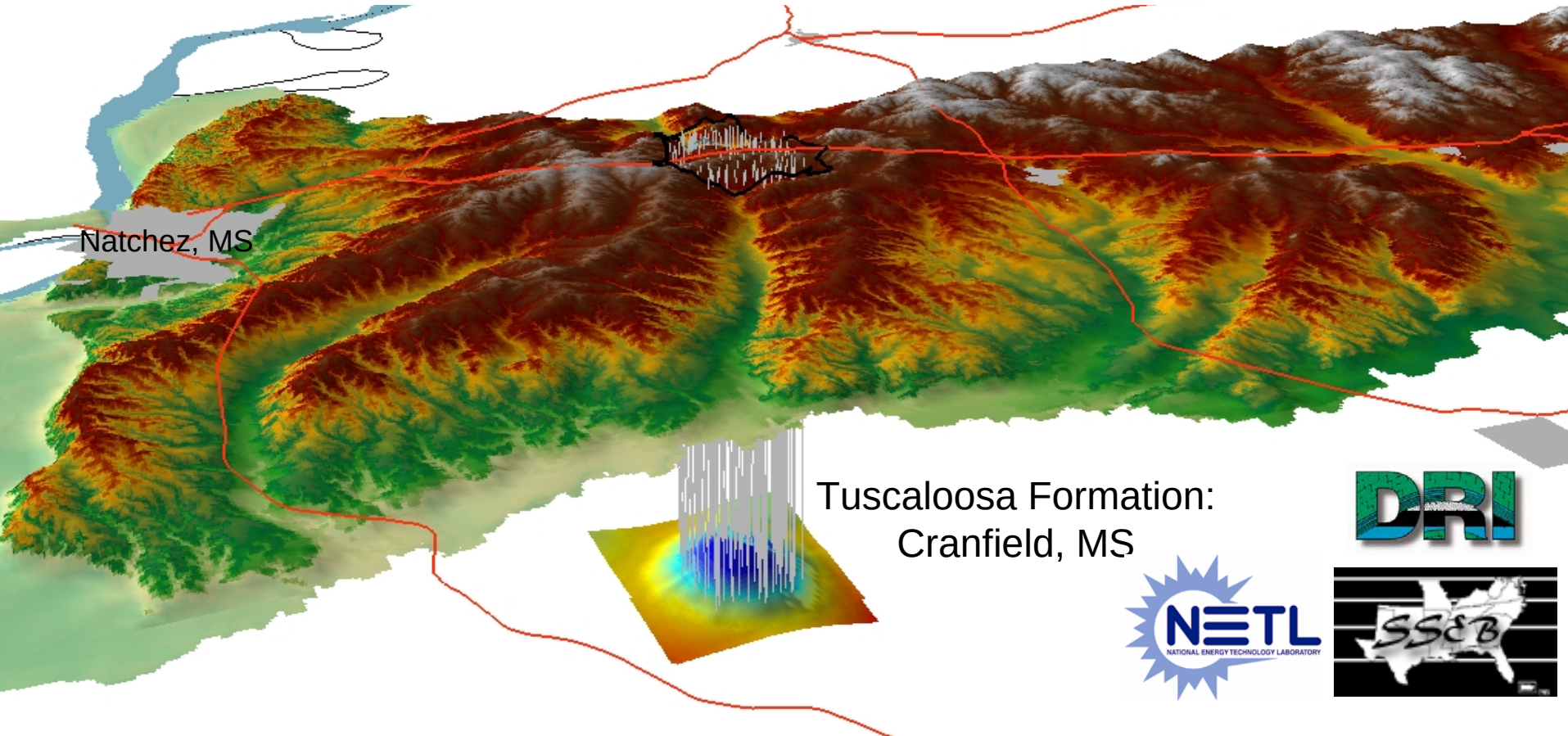




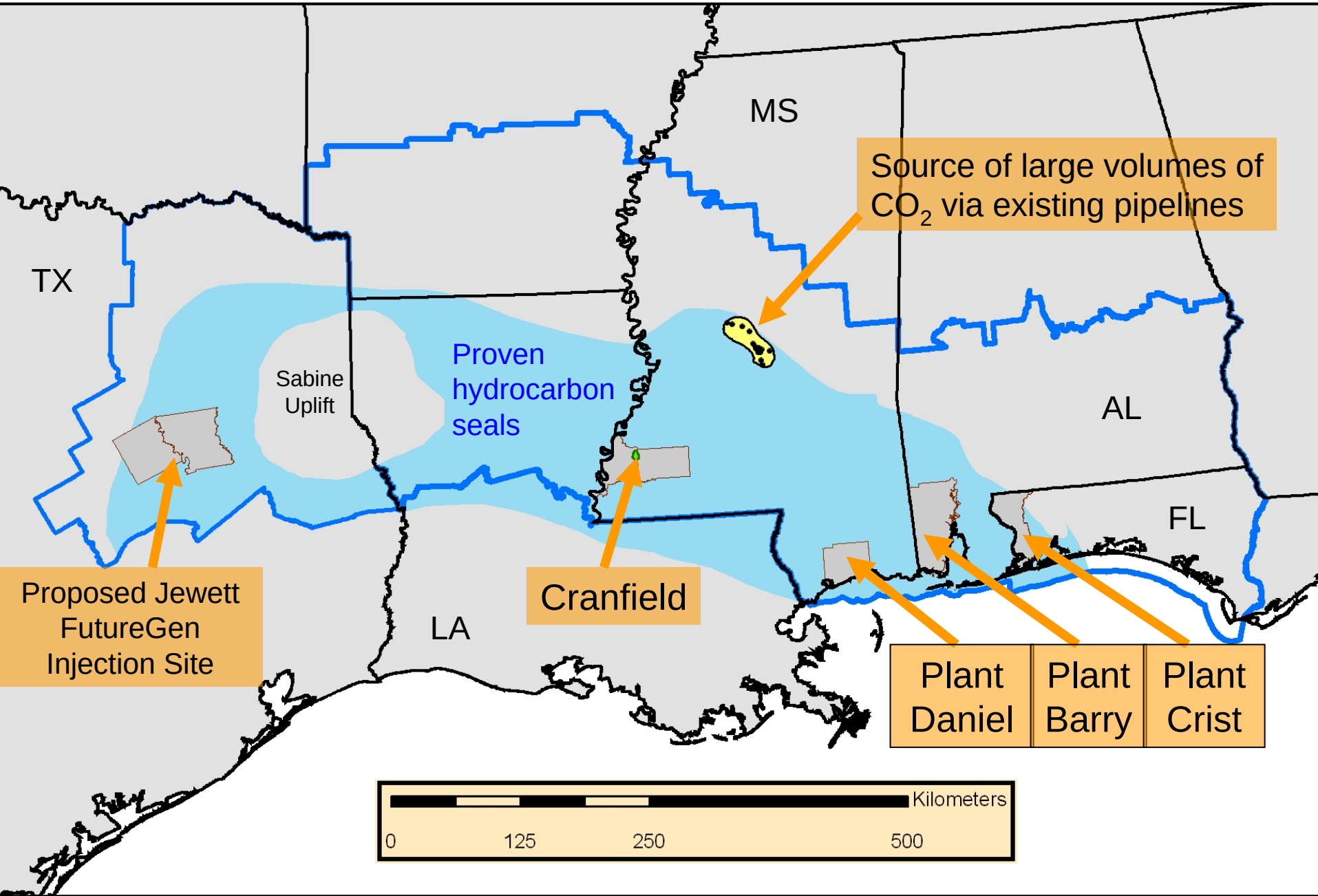
[From Daley et.al. 2007, in press]

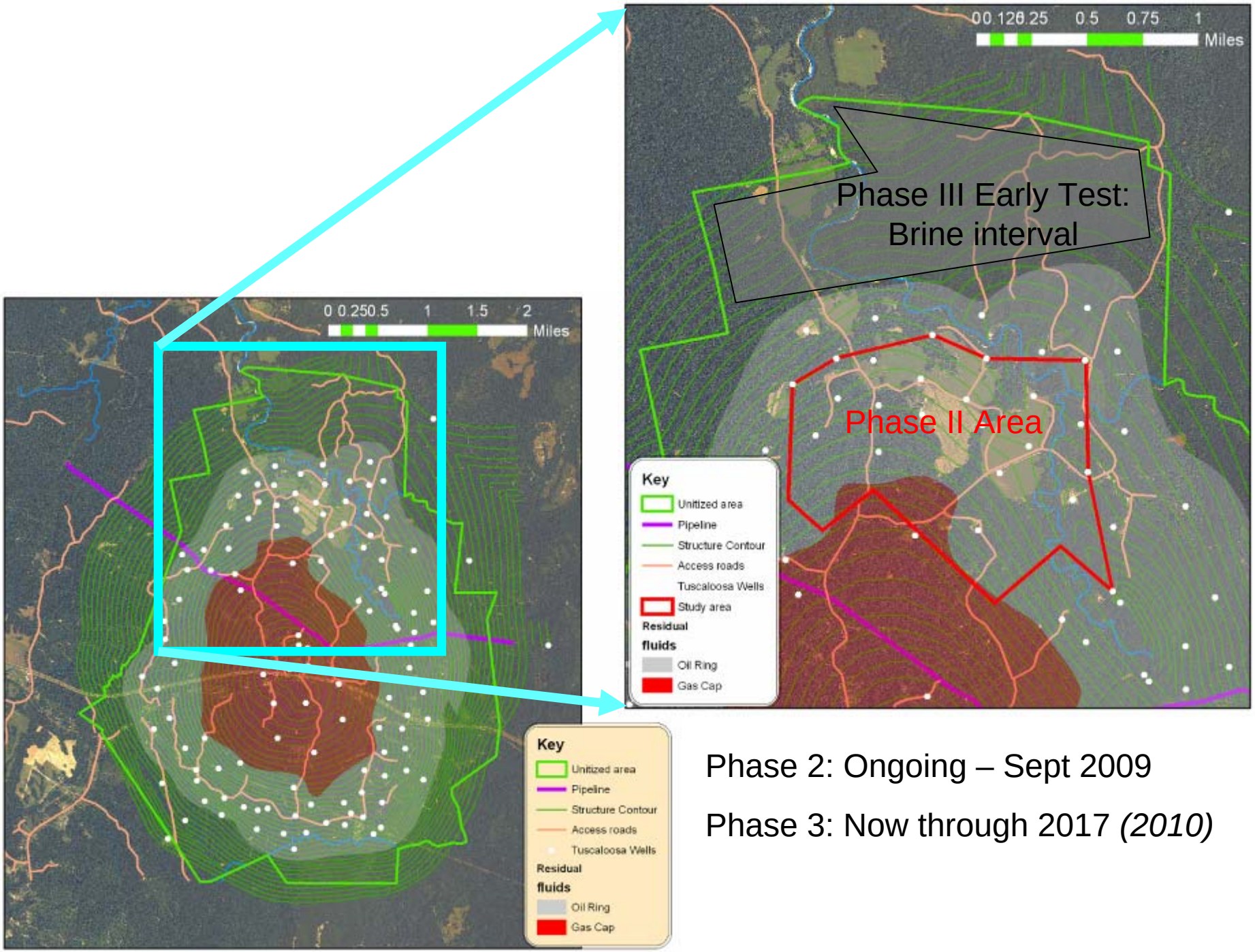
Gulf Coast Stacked Storage Field Test

Phase 2: $4.9M, Observation well & logging campaign
Phase 3: $38M, 2 monitoring wells, multiple injectors, 1 Mt/yr



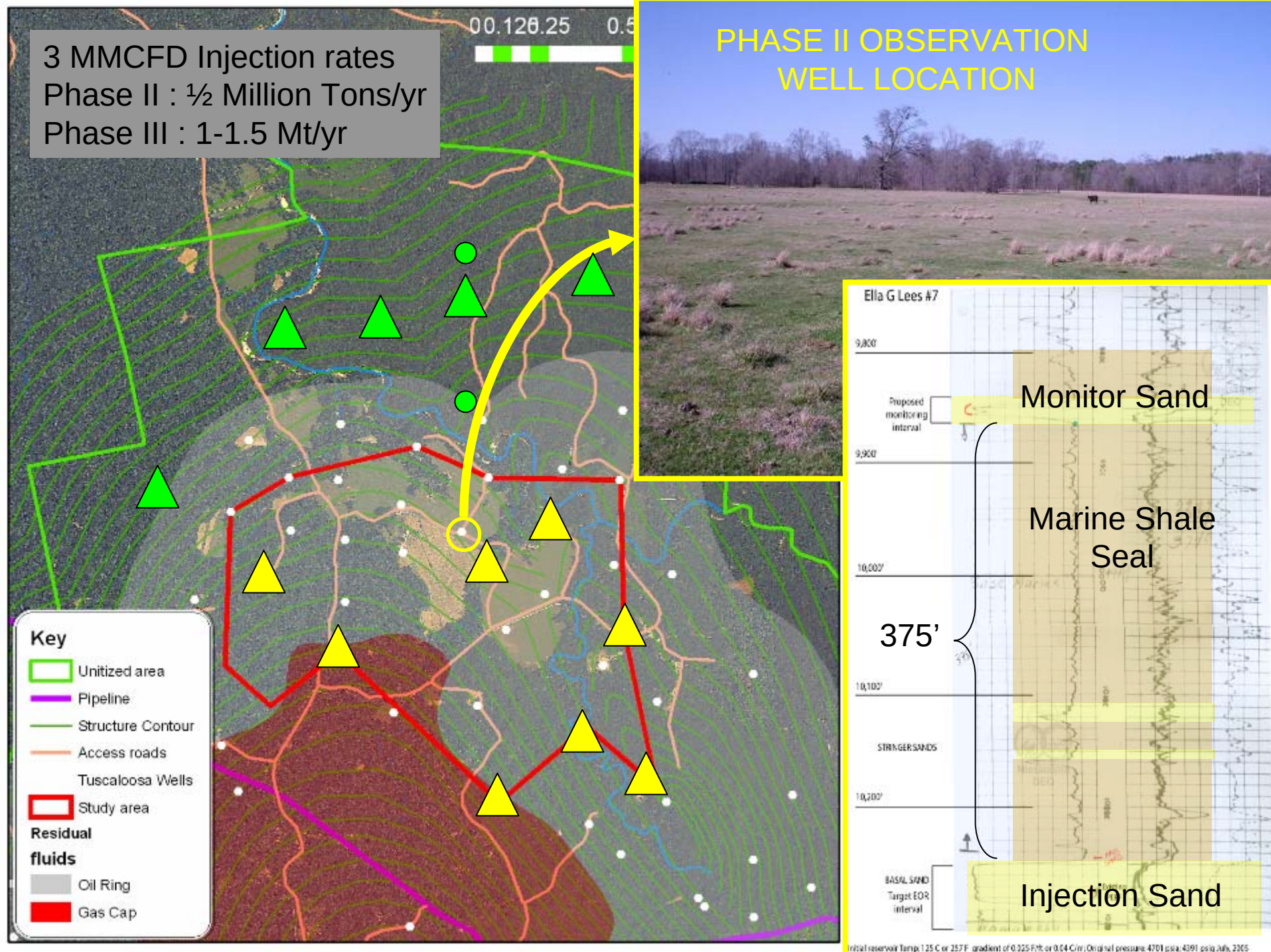
Geographic Focus of SECARB Phase III Program



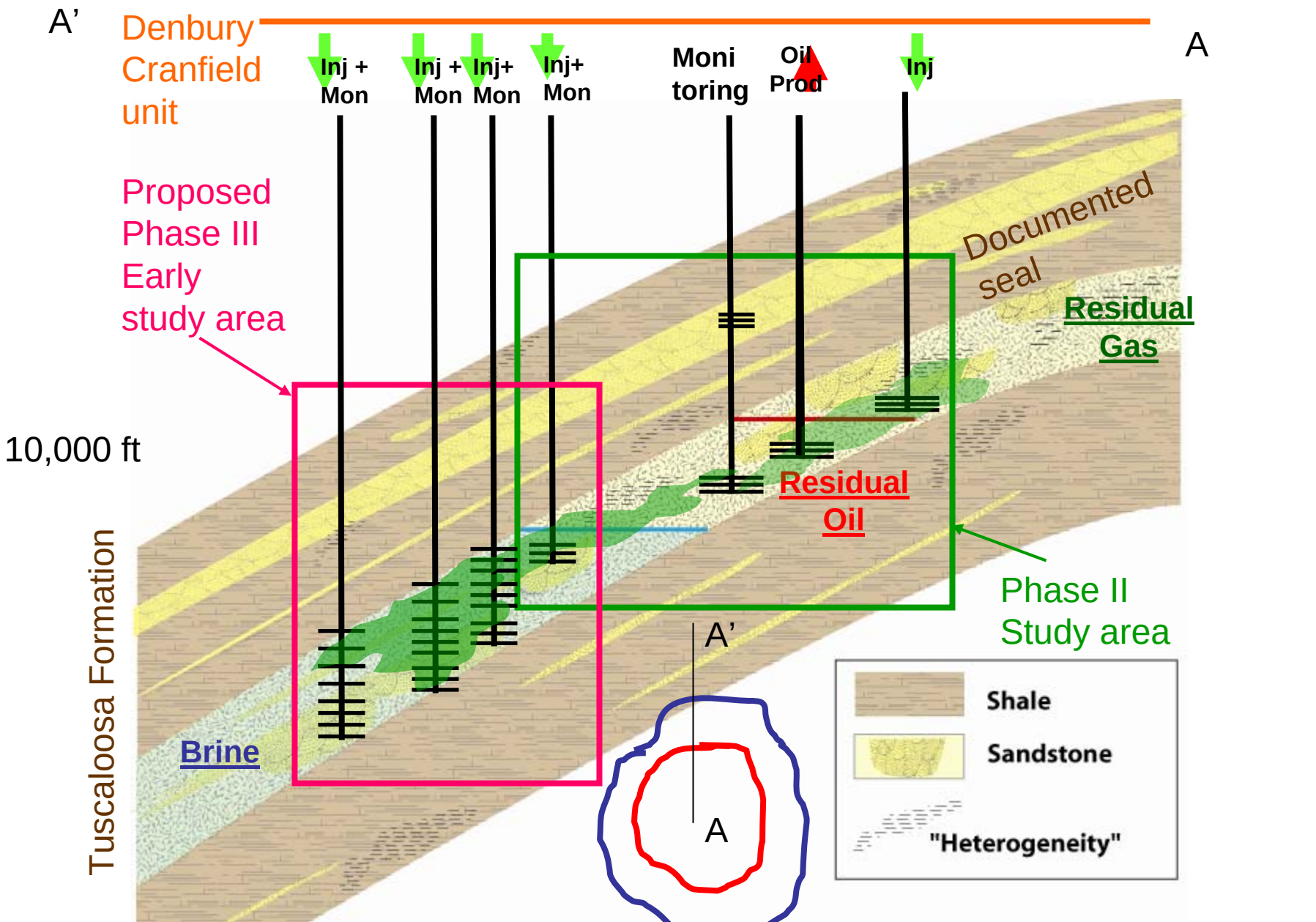


Phase 2: Ongoing – Sept 2009

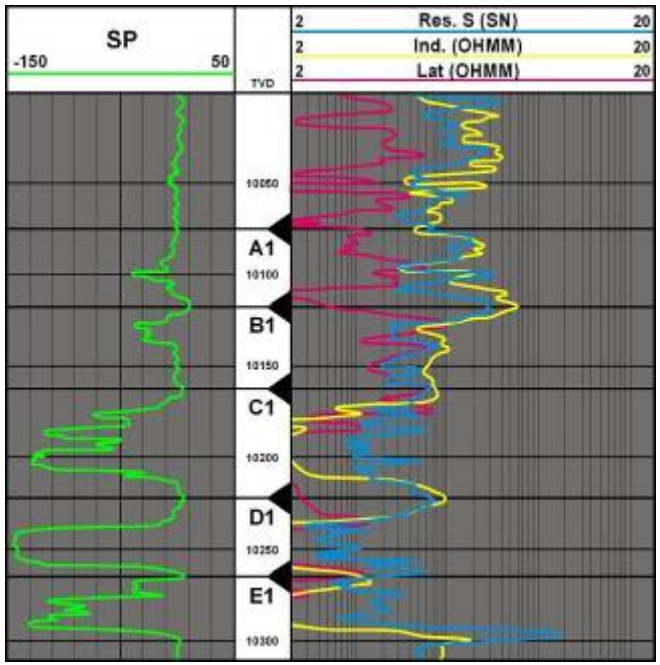
Phase 3: Now through 2017 *(2010)*

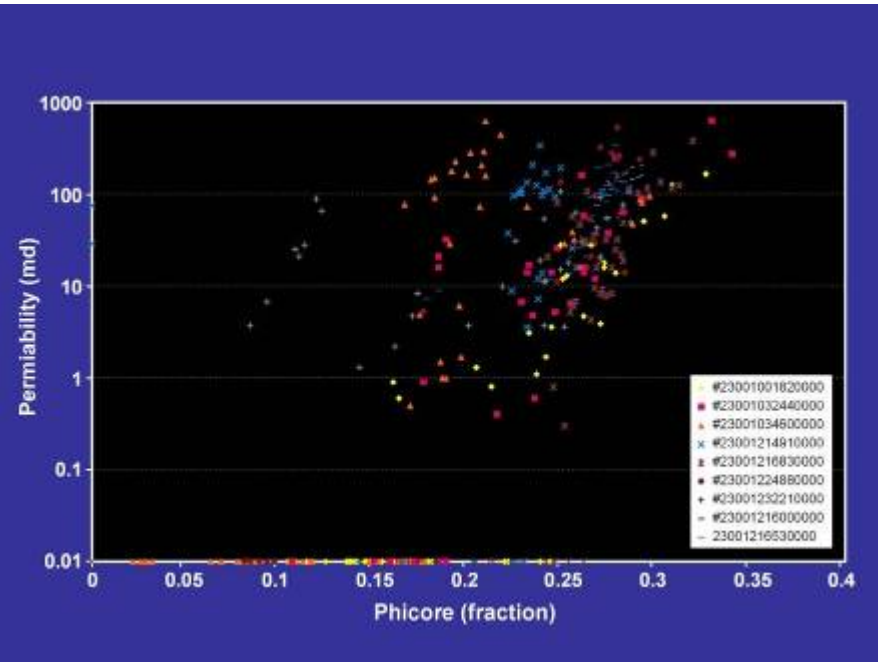

3 MMCFD Injection rates
Phase II : ½ Million Tons/yr
Phase III : 1-1.5 Mt/yr
0 0.125 0.25 0.5
PHASE II OBSERVATION WELL LOCATION
Ella G Lees #7
9,800'
Proposed monitoring interval
9,900'
10,002'
375'
10,102'
STRINGER SANDS
10,202'
BASAL SAND
Target EOR interval
Monitor Sand
Marine Shale Seal
Injection Sand
Key
Unitized area
Pipeline
Structure Contour
Access roads
Tuscaloosa Wells
Study area
Residual fluids
Oil Ring
Gas Cap

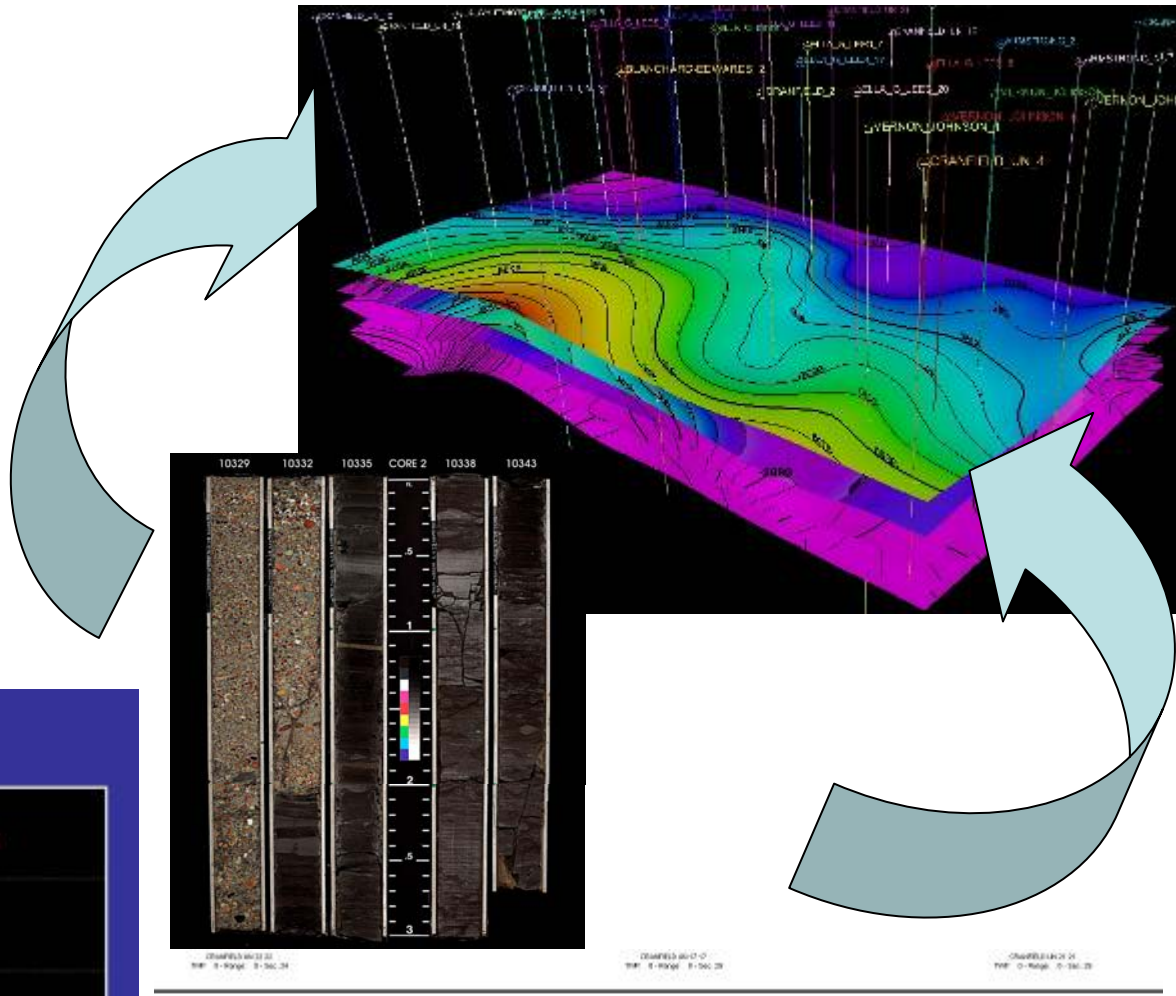
Cranfield Program Overview

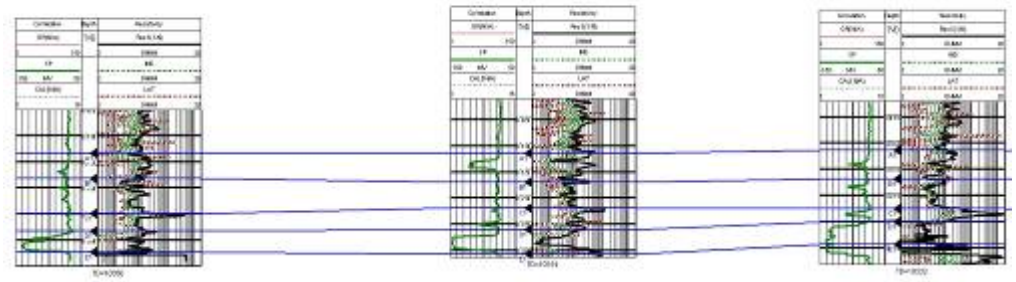


State of the art reservoir characterization and modeling approach





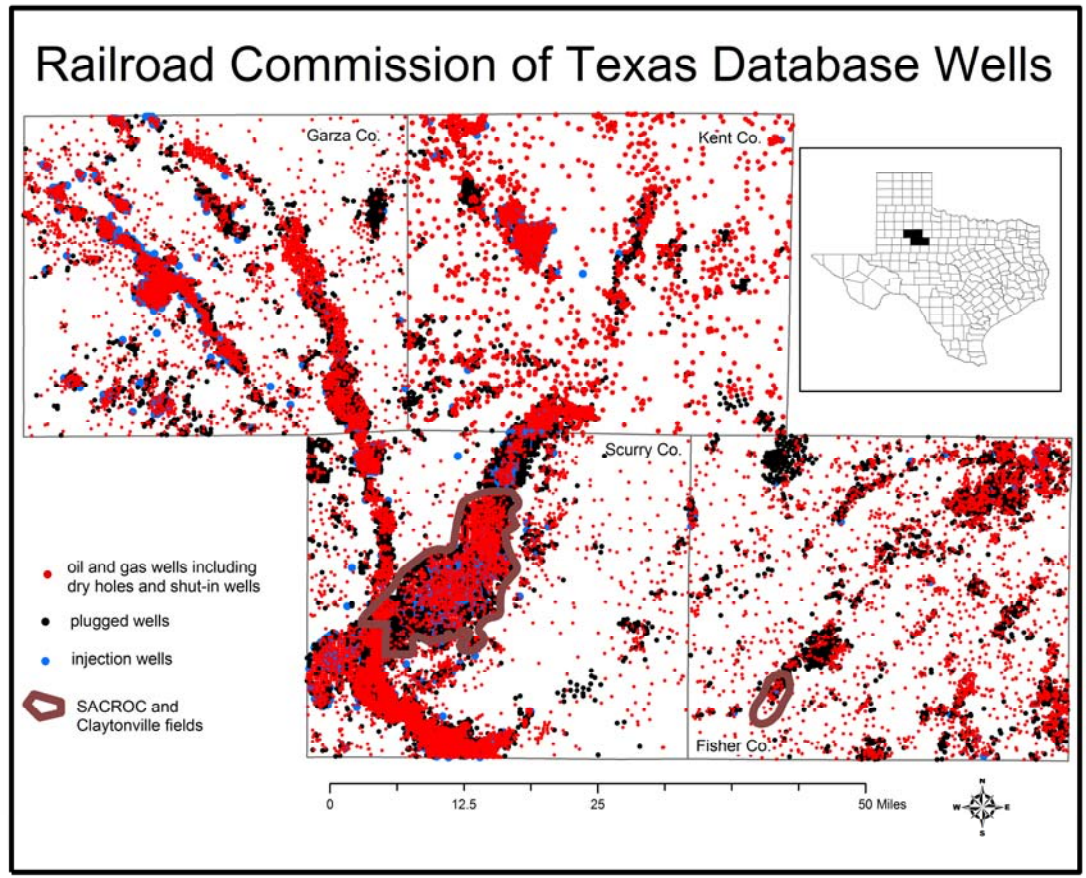




SWCARB Regional Partnership

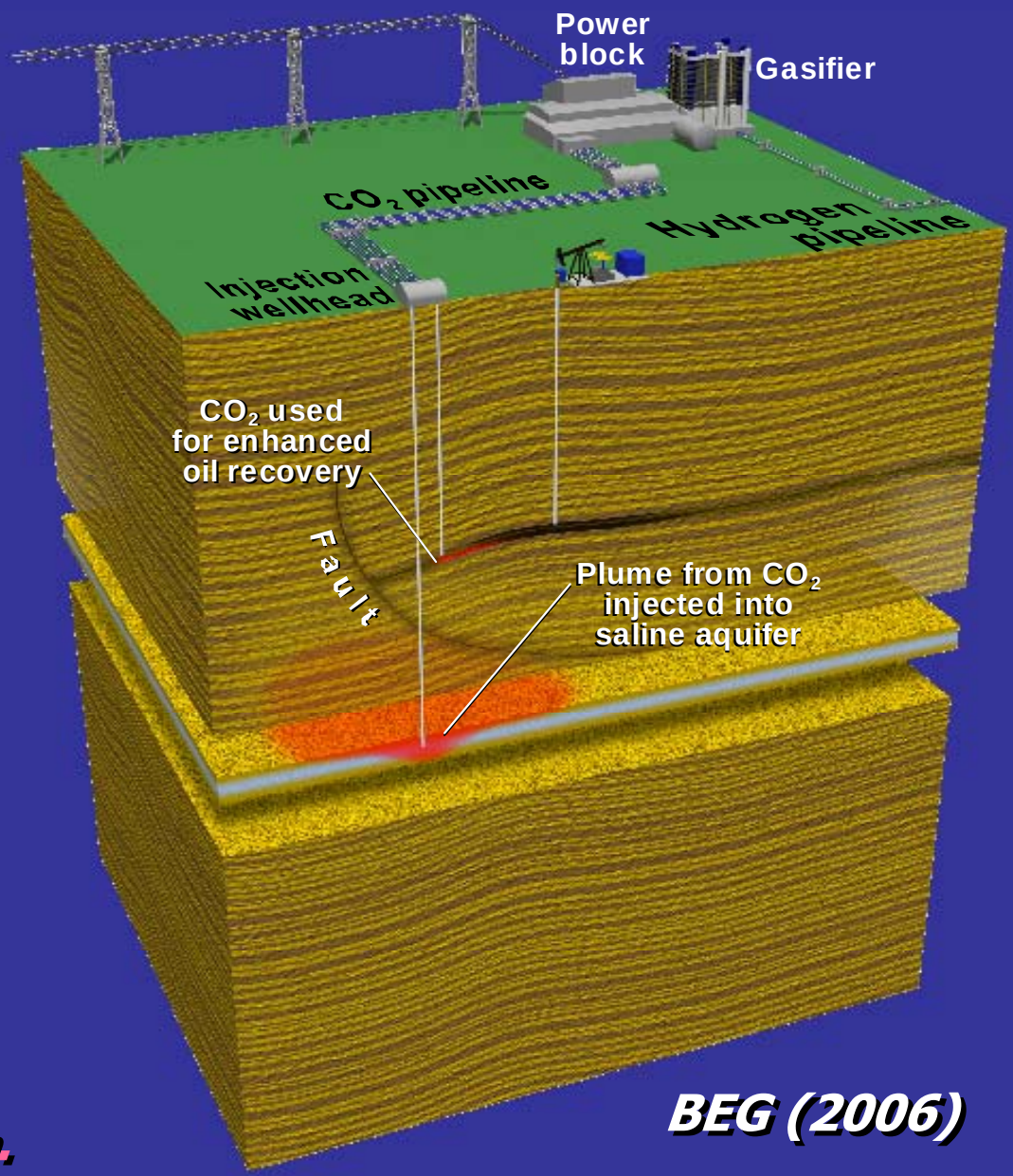
- SACROC
- Impact of 35 years of CO2 injection on USDW?
- 140 Mt injected
- 60 Mt recovered

KINDER MORGAN



FutureGen

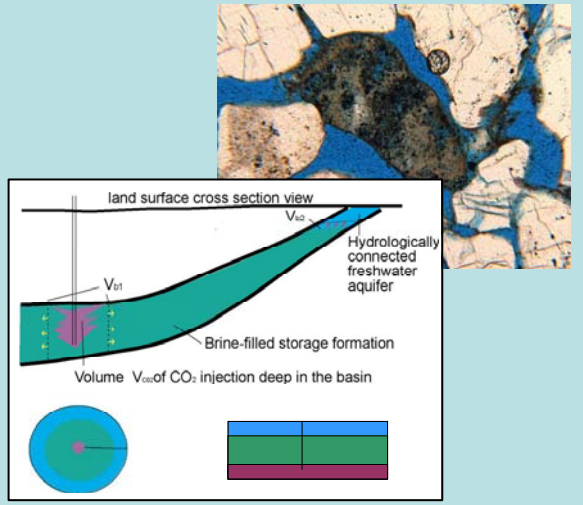
- 275-MW, near-zero-emission gasifier
- Flexible fuel source
- Produces electricity, H_2, >1MMT CO_2 per year
- CO_2 , H_2 pipelines
- Sequester ≥90% CO_2
- Protocols for CO_2 measuring, monitoring, and verification
- Stacked storage
  - *-EOR*
  - *-Deep brine-bearing fm.*

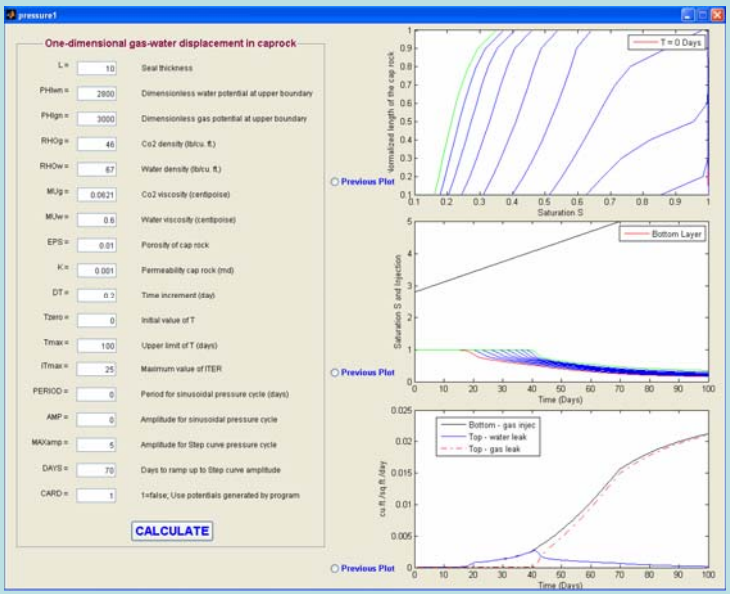


BEG (2006)

Key Geoscience Research Areas

- Potential negative impacts
  - Interaction with groundwater
  - Brine displacement
  - Leakage: abandoned wells





- Pressure evolution & seal integrity
- Multi-phase fluid flow modeling

Gulf Coast Carbon Center (GCCC)

Gulf Coast Carbon Center

Mission: ***Global leadership in research and economic implementation of large scale greenhouse gas sequestration.***

Bureau of Economic Geology

NETL National Energy Technology Laboratory

GCCC Team:

Ian Duncan, Susan Hovorka, Tip Meckel, Becky Smyth, J. P. Nicot, Jeff Paine + 4 new post-docs, MA student, URA

Steve Bryant & Gary Rochelle (UT- Chem. Eng.)

Department of Energy, United States of America

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