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SECARB's Mississippi SalineTest Site: A Field Project Update

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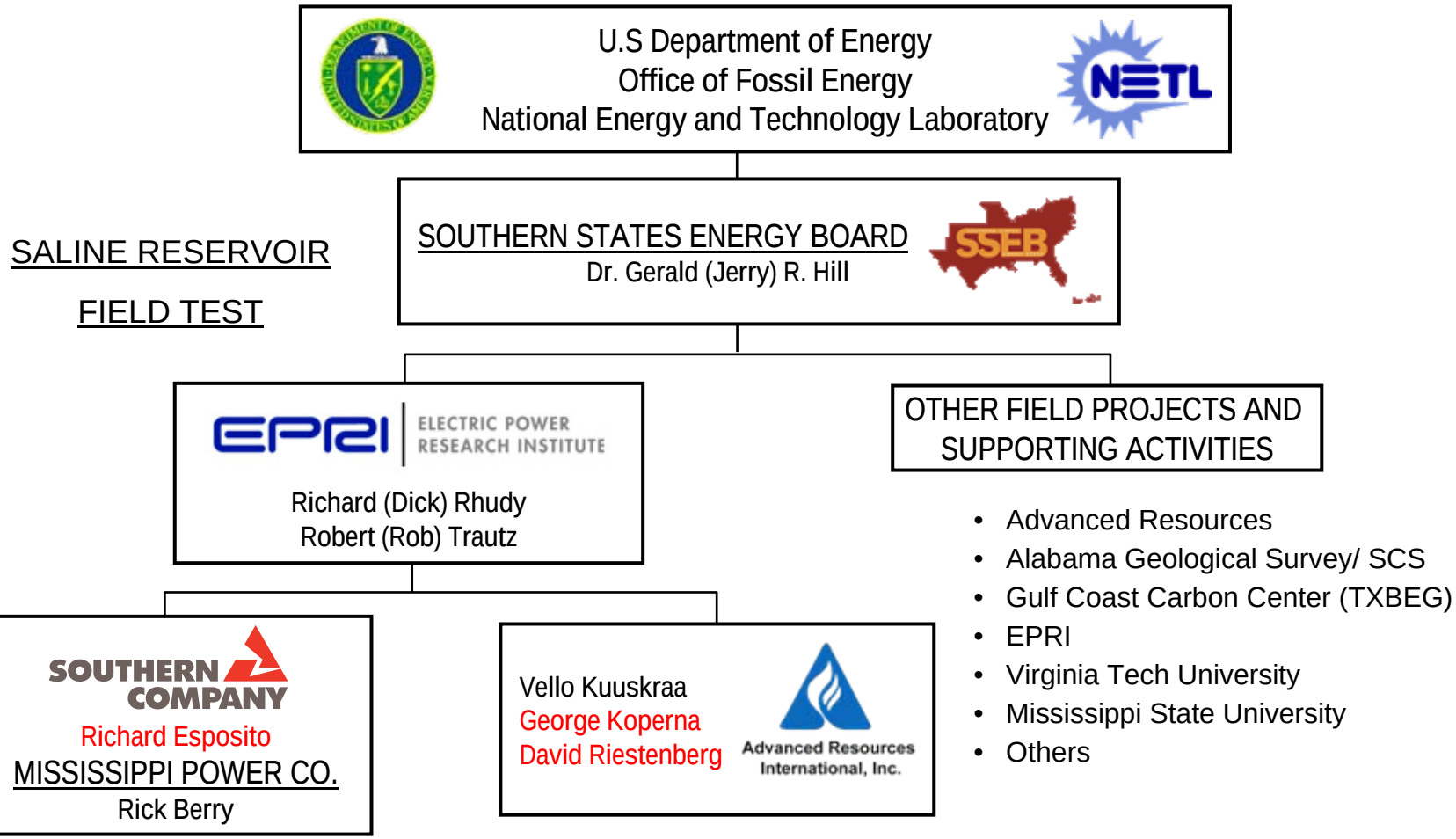
NETL

SECARB
Southeast Regional Carbon Sequestration Partnership

Outline

1. Introduction
2. Well Drilling & Completion
3. Reservoir Characterization
4. CO_2 Injection Operations
5. Monitoring and Verification

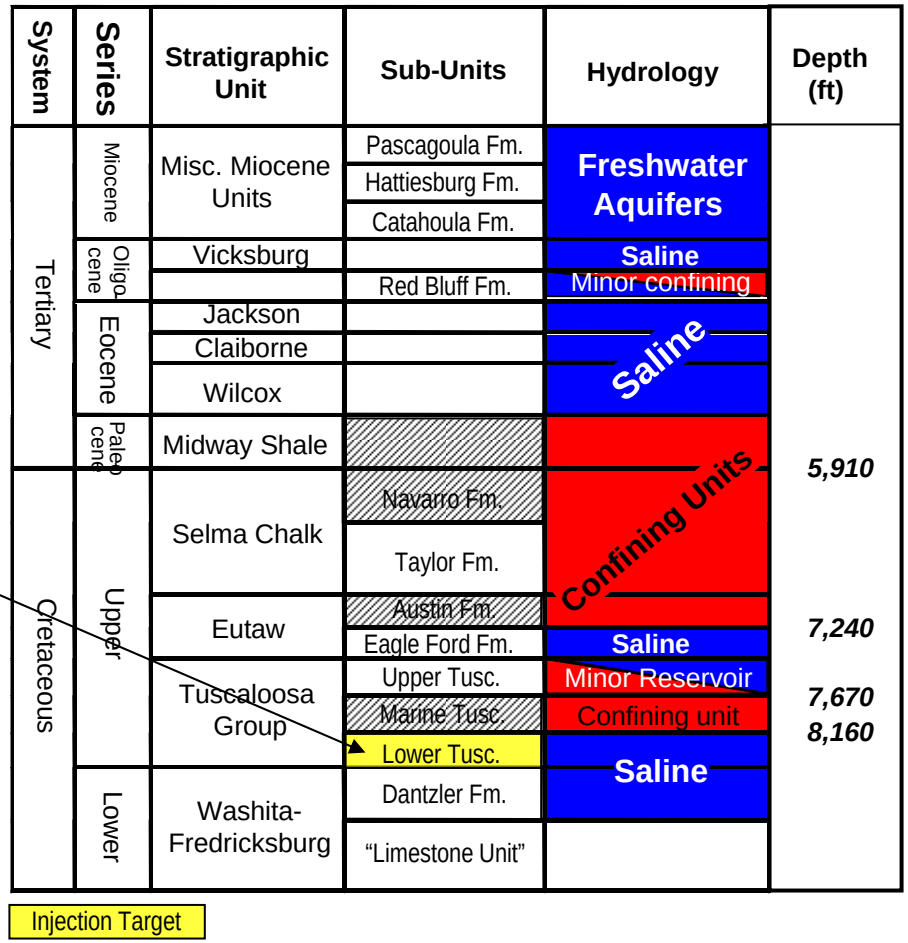
Key Organizations and Acknowledgments



Mississippi Saline Reservoir CO_2 Injection Project

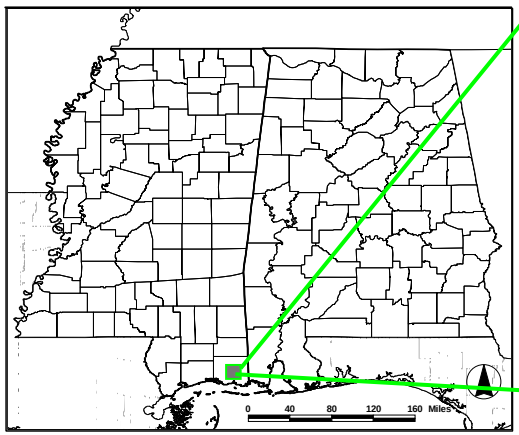
- **Purpose:** Validate sequestration opportunities in the Southeast region proximate to large coal-fired power plants
- **Initial Target:** Deep saline reservoirs along MS Gulf Coast
- Lower Tuscaloosa Massive Sand Unit (U. Cretaceous)
- **Confining Units (Seals):**
  - Marine Tuscaloosa
  - Austin Formation (Fm.)
  - Selma Chalk/Navarro Fm.
  - Midway Shale

(SE Mississippi)



Site Location

Victor J. Daniel Power Plant located in Jackson County, Mississippi.



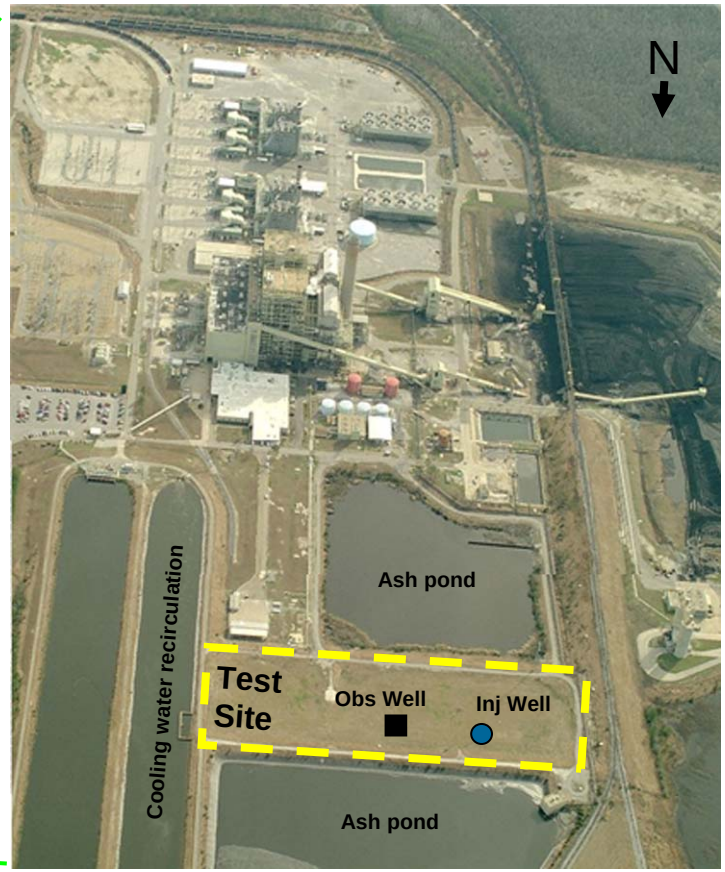


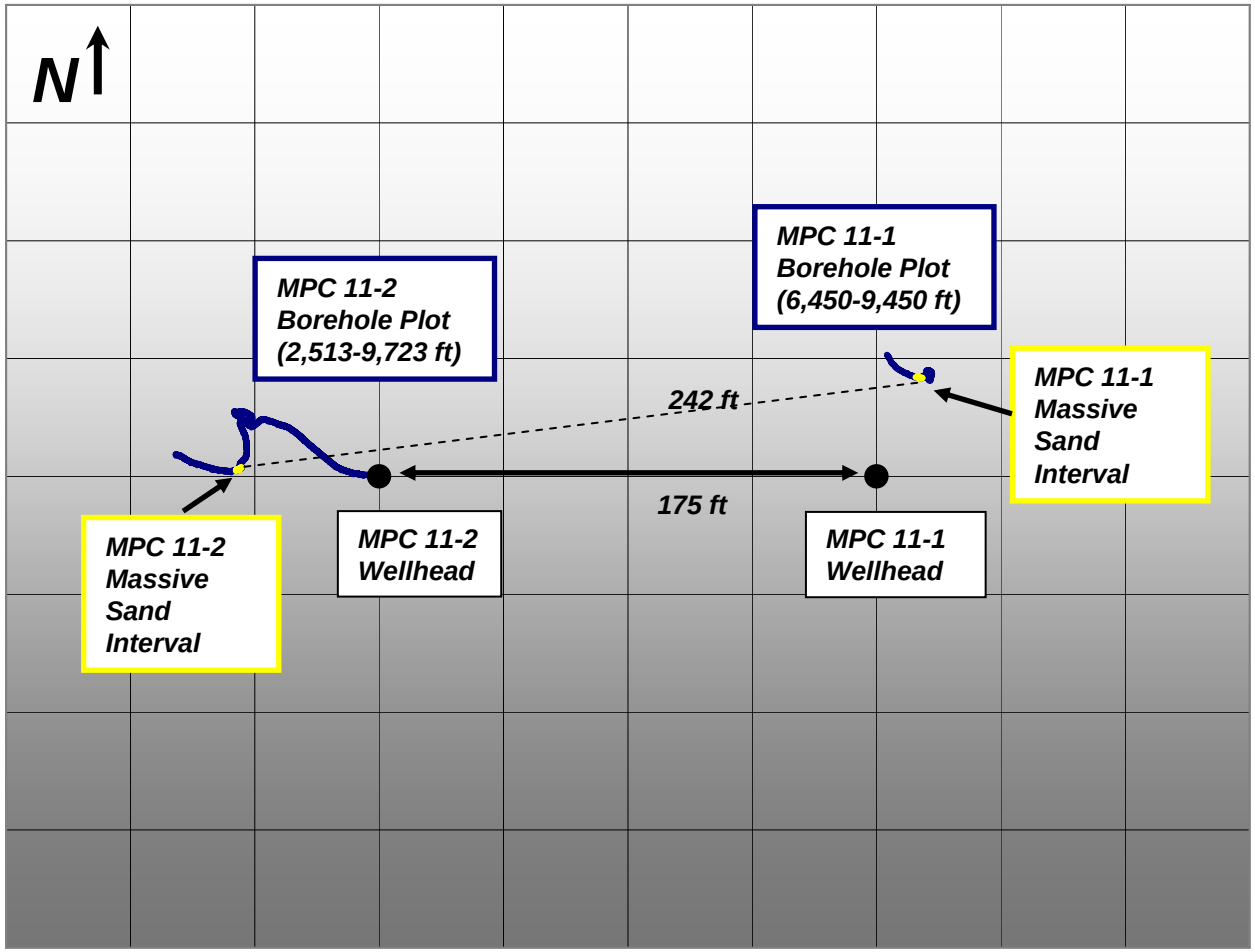
Image Source: Google Earth

Site Preparation and Drilling (Feb-Apr 2008)

- Observation well (11-1), TD=9500’
- Injection well (11-2), TD=9723’

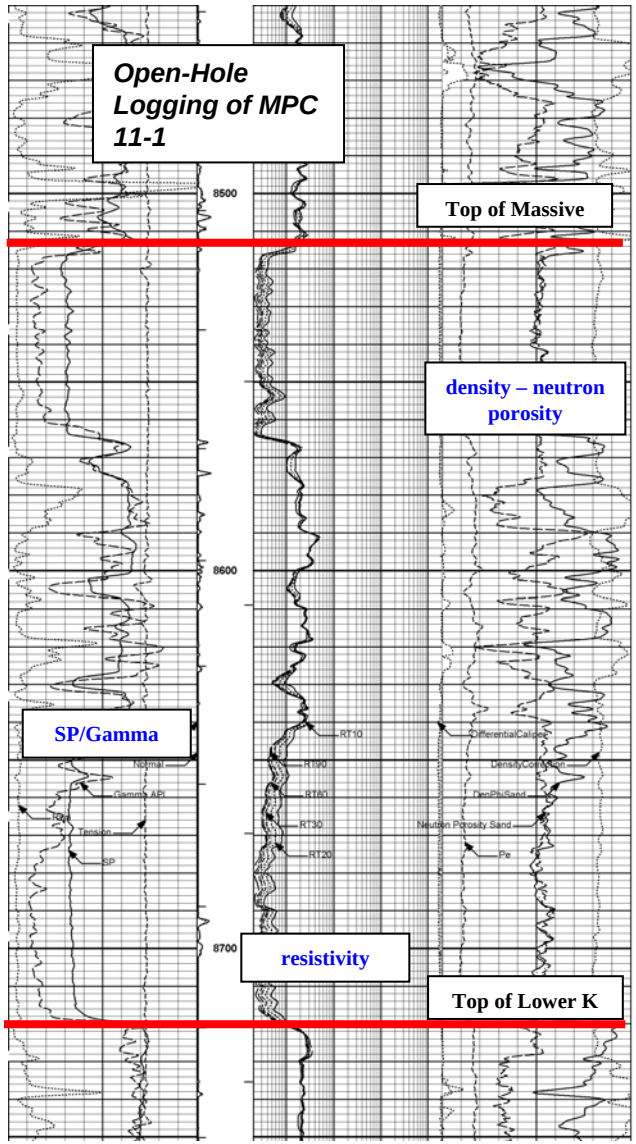
Borehole Deviation

- Distance between wells at the:
  - Surface 175 ft
  - Tusc. massive sand interval 242 ft

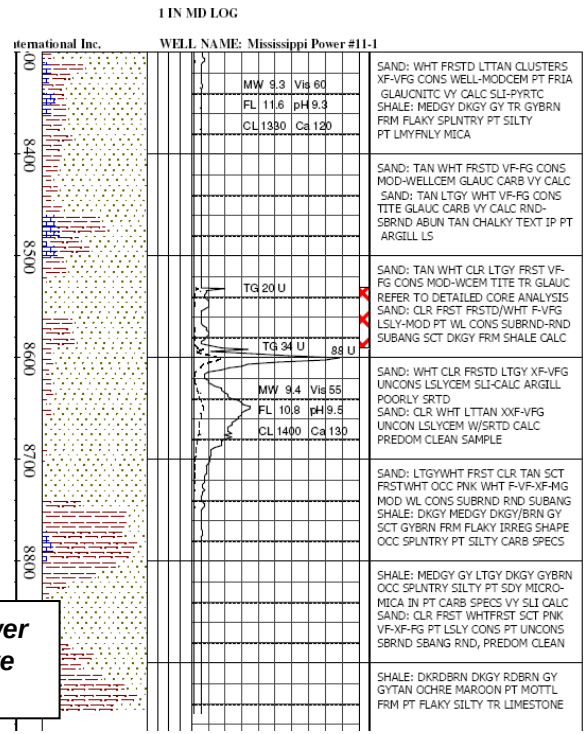


Borehole Deviation Survey

Reservoir Characterization (Obs. Well 11-1)



- Mud Logging (6,000 ft to TD)
- Wireline Logs
  - Gamma ray, resistivity, and density-neutron porosity
  - Cement Bond Log with Cast V Evaluation
  - Thermal Decay Log (gas saturation, S_g)

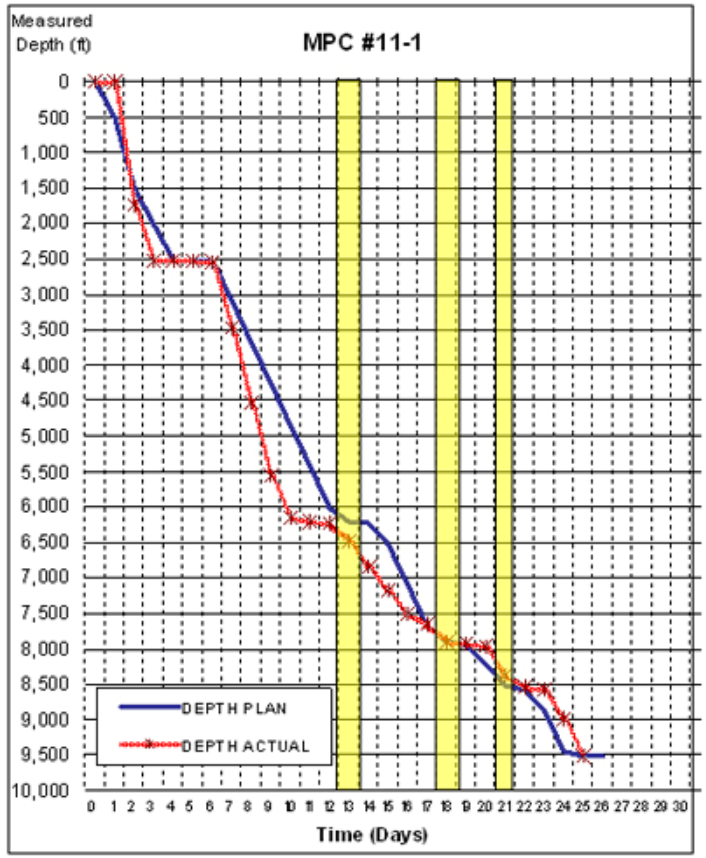


Mud Log of the Lower Tuscaloosa Massive Sand, MPC 11-1

Reservoir Characterization Whole Core (Obs. Well)

- Nearly 120 feet of whole core
  - Selma (30’/27’)
  - Marine Shale (28’/26’)
  - Tuscaloosa Massive Sand (60’/58’)
- Four inch dia. core

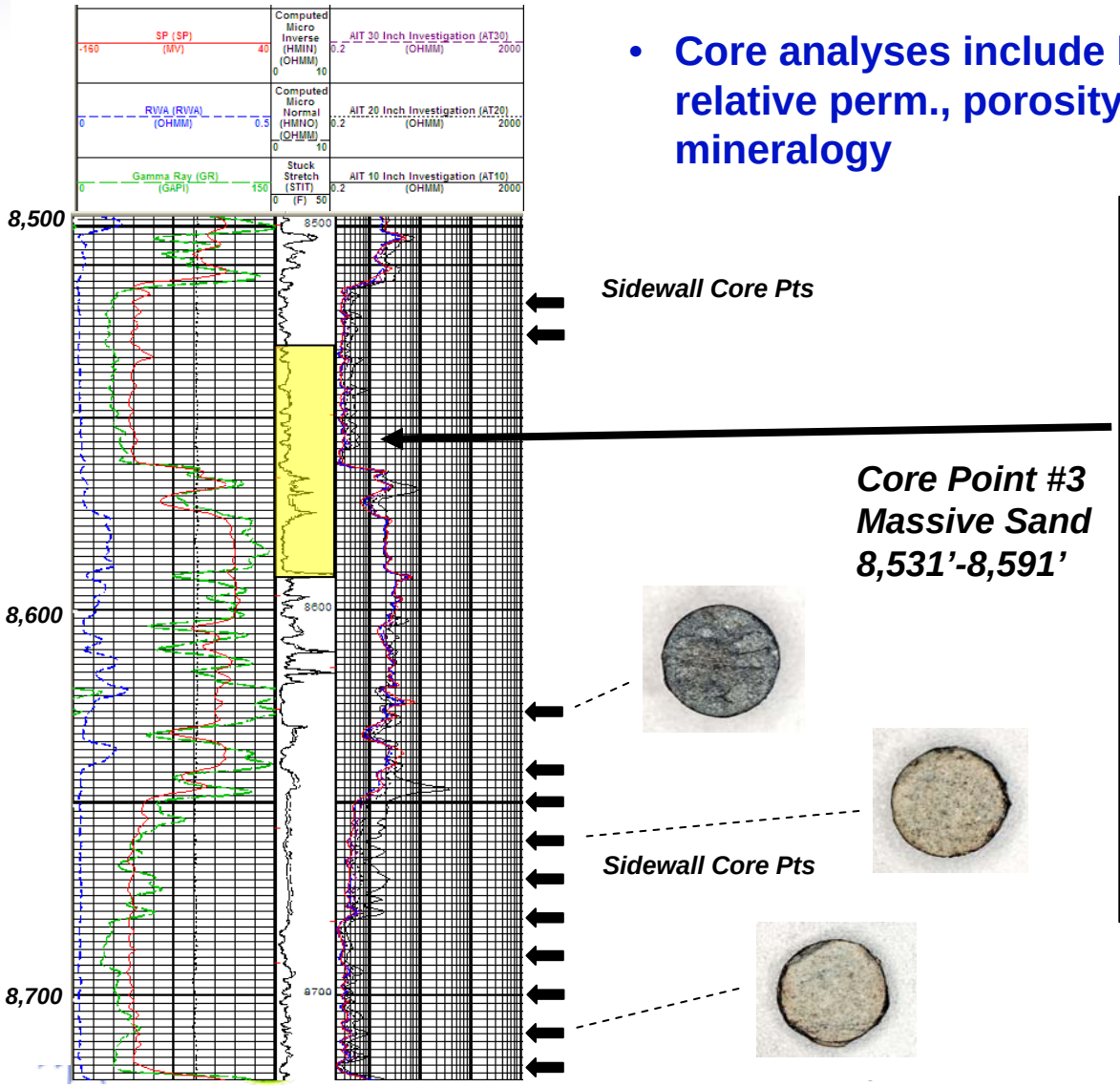
Marine Shale Whole Core MPC 11-1



Drilling Penetration Rates

Lower Tuscaloosa Massive Sand Storage Reservoir

- Core analyses include horizontal and vertical perm., relative perm., porosity, capillary pressure, and mineralogy



Core Point #3
Massive Sand
8,531'-8,591'

60 ft whole-core sample was taken from MPC 11-1 (~57' recovery)

Reservoir Characterization from Whole Core

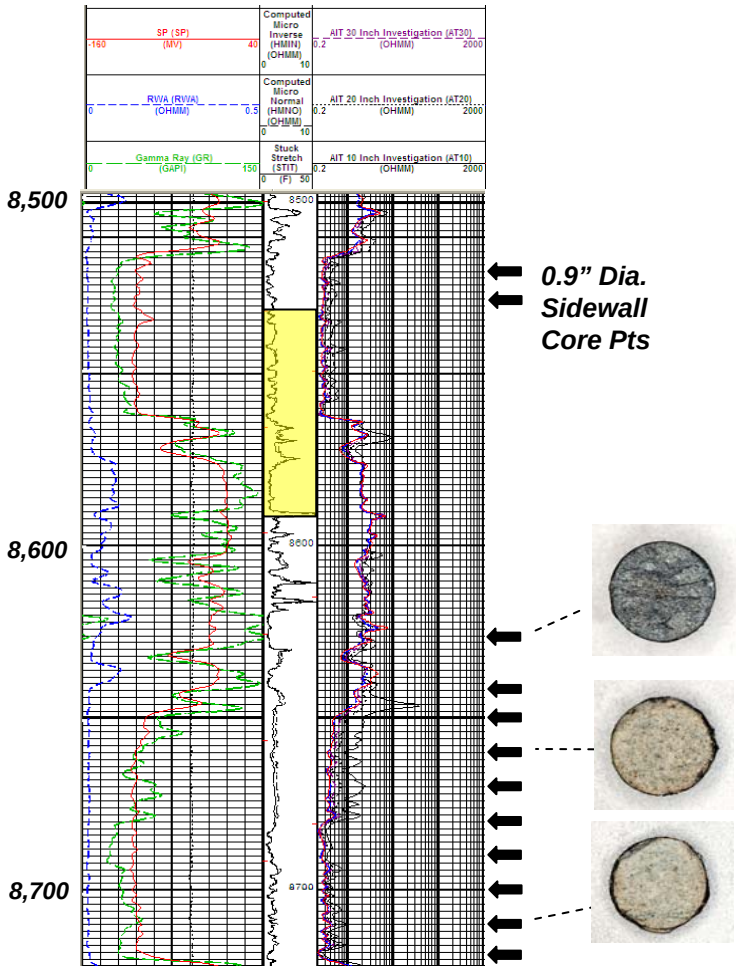
Lower Tuscaloosa Massive Sand Storage Formation

Core Number	Sample Number	Sample Depth, (ft)	Permeability millidarcys, to Air	Permeability millidarcys, Klinkenberg	Porosity, percent Ambient	Porosity, percent 2500 psi	Grain Density, gm/cc
3	3-1	8531.45	1450.	1380.	22.7	22.4	2.65
3	3-5	8535.50	2390.	2300.	24.5	24.2	2.64
3	3-9	8539.50	1930.	1850.	24.1	23.8	2.65
3	3-13	8543.45	652.	614.	19.7	19.4	2.67
3	3-17	8547.50	1460.	1400.	23.8	23.5	2.65
3	3-21	8551.50	936.	888.	23.2	22.9	2.65
3	3-25	8555.50	848.	804.	22.8	22.5	2.66
3	3-29	8559.50	1030.	977.	24.4	24.1	2.65
3	3-33	8563.50	641.	603.	23.4	23.1	2.65
3	3-37	8567.50	3390.	3280.	25.3	25.0	2.65
3	3-41	8571.40	0.0082	0.0028	7.8	7.5	2.71
3	3-45	8575.50	7.16	5.63	17.9	17.6	2.68
3	3-49	8579.50	+		9.1		2.75
		Average values:	1230.	1180.	20.7	21.3	2.66

\+ Indicates the sample is unsuitable for this type of measurement

Reservoir Characterization (Inj. Well 11-2)

- Wireline Logging included:
  - Schlumberger's Platform Express Log
  - Thermal Decay Log
  - Mechanical Properties Log
  - Combinable Magnetic Resonance
  - Elemental Capture Spectroscopy
  - Cement Bond Log with Cast V Evaluation
- 30 sidewall cores
  - 6 marine shale, 12 massive sand
- Baseline water sampling (June 2008)
- 2-day pressure transient test (June 2008)



Selected Sidewall Core Locations From Injection Well 11-2

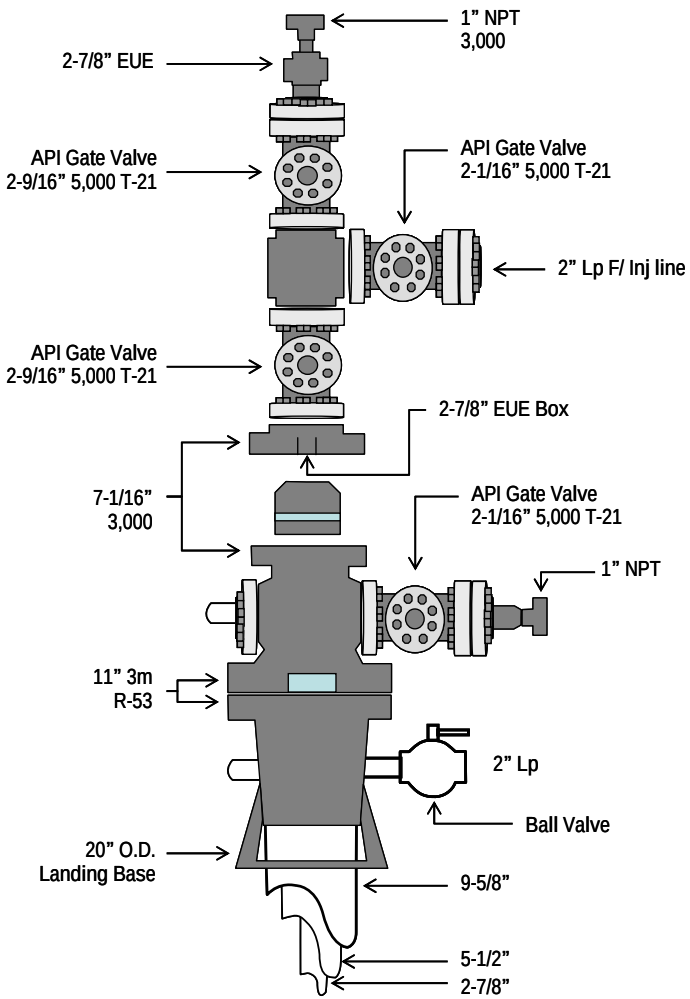
Summary of Sidewall Core Results

In. Rec.	Sample Depth Feet	Permeability mD	Porosity %
Lower Tuscaloosa Marine Shale			
0.0	7910.0		
1.7	7920.0	<0.1	8.2
1.4	7930.0	<0.1	9.2
1.4	7976.0	<0.1	8.8
0.0	7986.0		
1.5	7996.0	<0.1	8.3
Lower Tuscaloosa Interbeds			
0.9	8500.0	5.1	17.4
1.6	8510.0	<0.1	9.6
0.8	8520.0	420.0	20.3
0.9	8530.0	800.0	22.9
Massive Sand Interlobe			
1.0	8630.0	3.8	16.5
0.8	8642.0	9.5	18.6

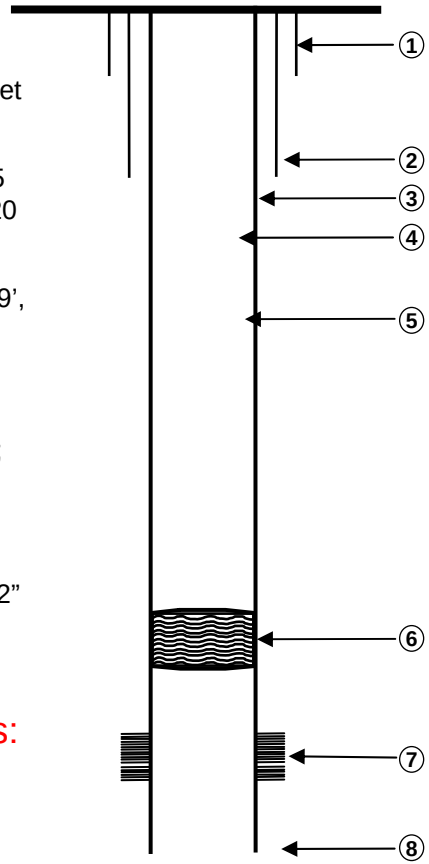
In. Rec.	Sample Depth Feet	Permeability mD	Porosity %
Massive Sand Lower Lobe			
0.8	8650.0	450.0	23.2
1.1	8660.0	550.0	23.4
0.8	8670.0	300.0	22.5
1.1	8680.0	900.0	23.3
0.6	8690.0	980.0	24.0
0.6	8700.0	175.0	19.3
0.9	8710.0	660.0	22.9
1.0	8720.0	600.0	21.6
Lower Cretaceous			
0.9	8820.0	3.0	17.5
0.5	8830.0	56.0	20.0
1.5	8840.0	1000.0	23.1
1.0	8850.0	950.0	22.8
0.0	8860.0		
1.0	9010.0	525.0	22.4
1.0	9020.0	1050.0	22.1
1.1	9030.0	775.0	22.9
1.0	9040.0	580.0	23.1
1.2	9050.0	1050.0	24.4

Injection and Observation Wells Completed (June 2008)

INJECTION WELLHEAD ASSEMBLY



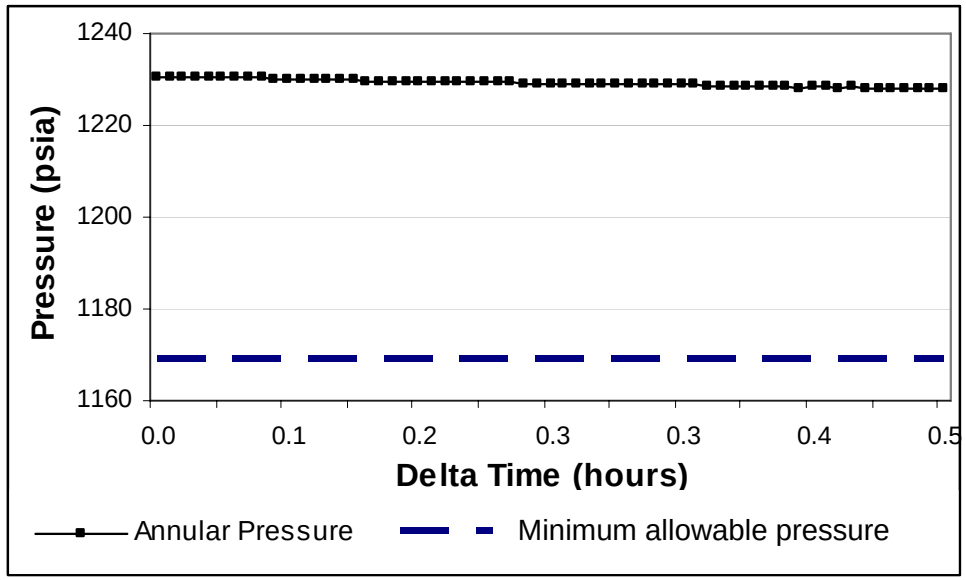
COMPLETION DETAIL



1. ~16" Conductor Pipe set at 90 feet
2. 9-5/8" Surface Casing @ 2,568', set in 12-1/4" hole; 40.0 lb/ft J-55 STC; Cemented to surface w/ 420 sacks.
3. 5-1/2" Protection Casing @ 9,669', set in 7-7/8" hole; 20.0 lb/ft N-80 LTC; Cemented to 1,100' w/ 975 sacks.
4. 2-7/8" Injection Tubing @ 8,500'; 6.5 lb/ft J-55 EUE 8rd.
5. Annular Fluid: TBD
6. Injection Packer @ ~8,500'; 5-1/2" x 2-7/8" retrievable production packer.
7. Perforated two intervals:
   8520-8560 ft
   8760-8710 ft
8. Total Depth @ 9,668'

Mechanical Integrity Testing (July 2008)

- Performed on injection well (MPC 11-2)
- The MIT included:
  - Annular Pressure Test
  - Temperature Log (checks for leaking tubing)
  - Radioactive Tracer Test (demonstrates injected fluids are ejected through the perforations into the injection zone)

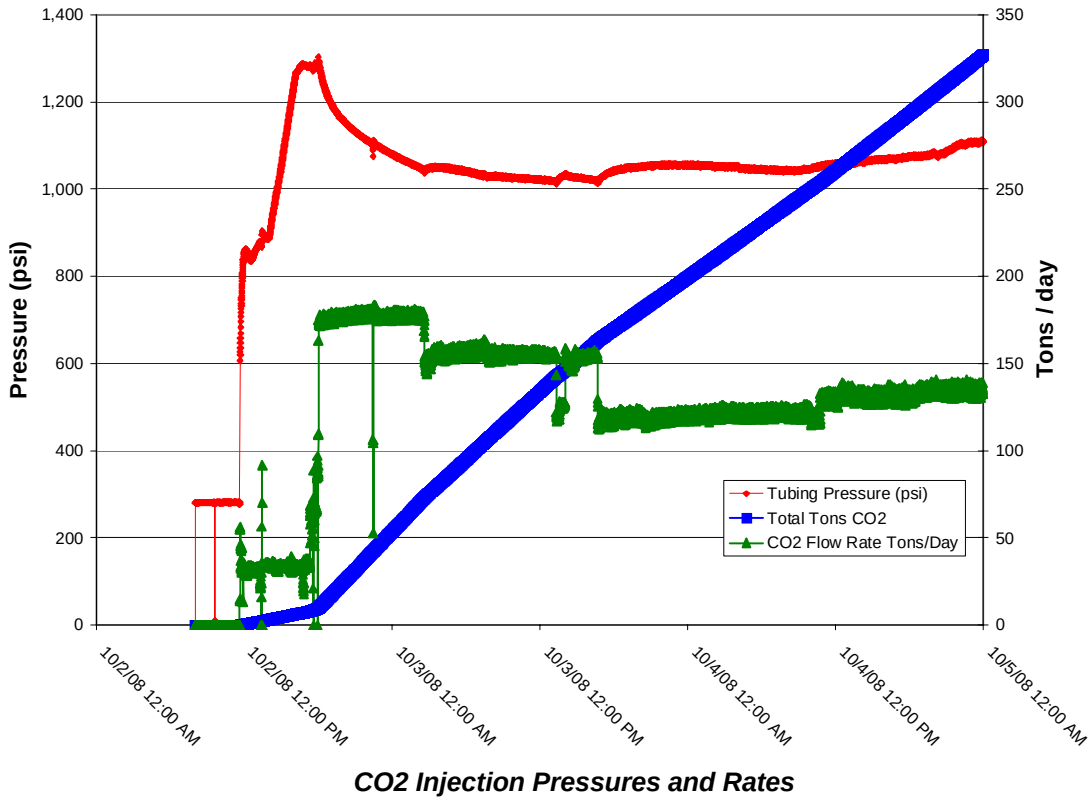


Pressure MIT results for injection well MPC 11-2

The tests were observed and certified by a MS Dept Environmental Quality

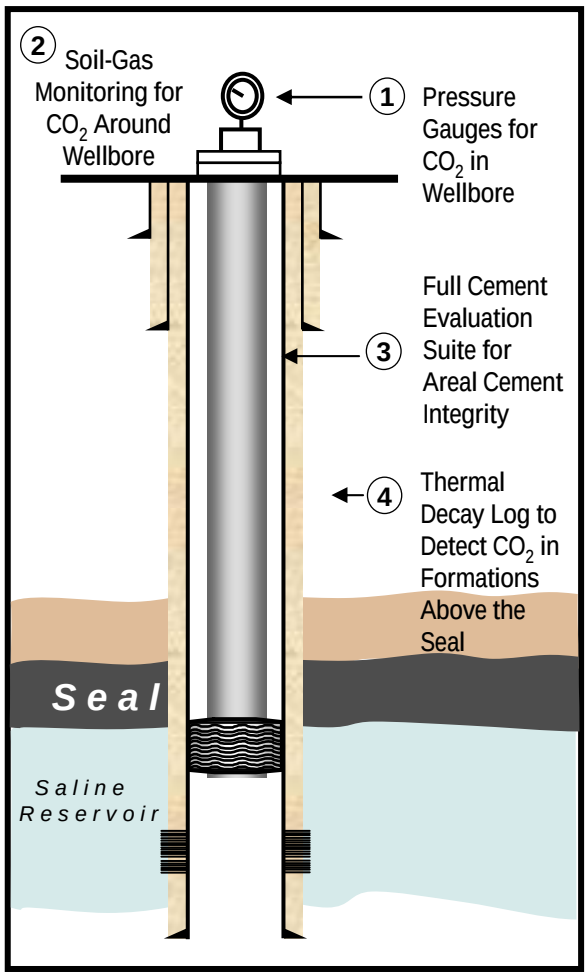
CO_2 Injection Underway!

- Injection started October 2nd
- Inject up to 3000 tons total
- Current rate of injection ~ 140 t / day
- CO_2 supply Denbury's pipeline outlet in central MS
- CO_2 deliveries Airgas Carbonic (7 loads per day)
- CO_2 stored on-site, heated and pumped into the formation by Reliant Gases.



CO2 Injection Pressures and Rates

Surface and Subsurface MMV to Assure Well Integrity



Surface and subsurface MMV methods:

1. Sustained casing and annular pressure
2. Near-surface CO_2 soil gas and tracer (PFT) measurements
3. Cement bond logs before and after CO_2 injection
4. Thermal Decay Logs to detect any CO_2 above the reservoir seal.

CO_2 Detection Using Soil Flux and Groundwater Monitoring

Permanent soil monitoring stations

Near-well soil monitoring stations (will be affected by drilling/injection operations

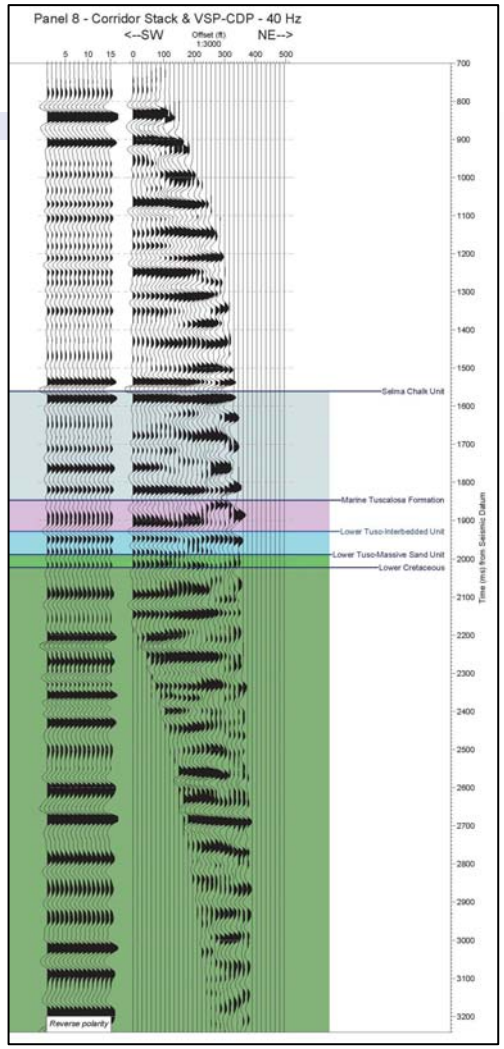
Soil monitoring stations within the drilling footprint (may be affected by drilling/injection operations)

Control soil monitoring stations

CO_2 Plume Monitoring

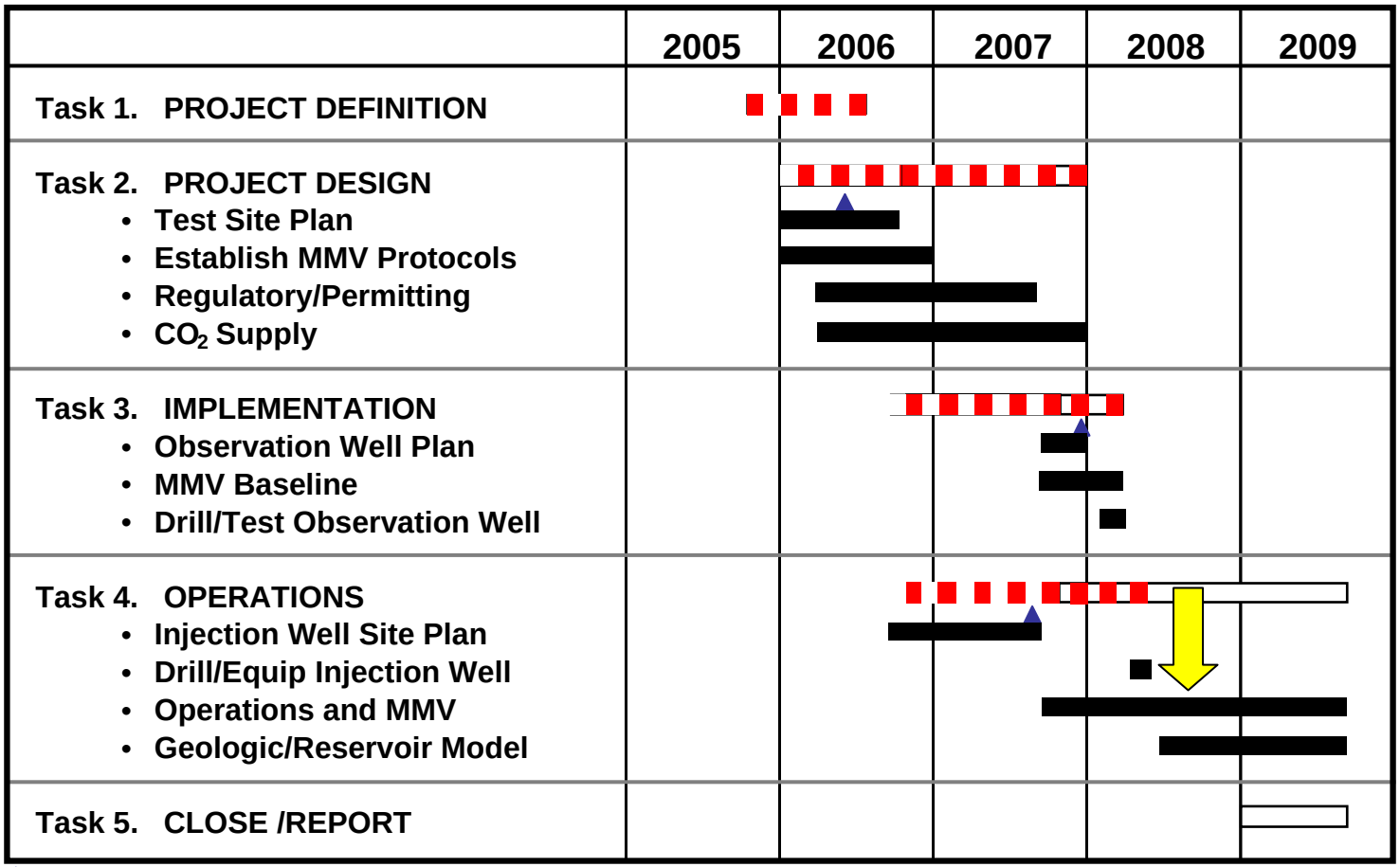
- Horizontal location
  - Vertical Seismic Profiles (VSP) before and after injection
- Vertical leakage
  - Time-lapse thermal decay logs (in both wells) before, during, and after injection

Vibroseis Trucks



Baseline VSP (May 2008)

Project Schedule



▲ Key Decision Milestones