Assessment of CO2 Storage Resources in Depleted Oil and Gas Fields in the Ship Shoal Area, Gulf of Mexico

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U.S. Department of Energy

National Energy Technology Laboratory

Mastering the Subsurface Through Technology, Innovation and Collaboration:
Carbon Storage and Oil and Natural Gas Technologies Review Meeting

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Presentation Outline

- Benefits, Goals and Objectives of the Project
- Background
- Technical Status
- Accomplishments To Date
- Synergy Opportunities
- Summary
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Benefit to the Program

The anticipated benefits to the OSRA program of the proposed project include:

- *Providing a more extensive and detailed geologic review and analysis of the Ship Shoal Area in the northern GOM. The improved prediction of CO2 storage capacity for this near-shore region may allow it to be considered as a potential commercial sequestration site by the 2025-2035 timeframe.*
- *The development and analysis of a combined CO2 migration model and geomechanical simulation approach will allow for the evaluation of plume migration, induced stresses and potential fault reactivation due to CO2 injection. The results of the modeling will be useful for the research community to inform, compare, and validate future CO2 sequestration developments.*

This project addresses program goals to estimate CO2 storage capacity of the Ship Shoal area to within ±30% accuracy and to ensure 99% storage permanence, ensuring containment effectiveness.

Project Overview:
Goals and Objectives

The primary goals are to identify storage capacity in Plio-Miocene structural traps throughout the Ship Shoal Area and to determine the risks associated with high volume CO2 storage.

Phase I

- Geologic data review;
- Geologic modeling;
- Storage capacity estimation; and
- Preliminary risk assessment.

Phase II

- Fluid flow and geomechanical modeling;
- Risk assessment;
- CO2 transportation; and
- Refined storage capacity estimation.

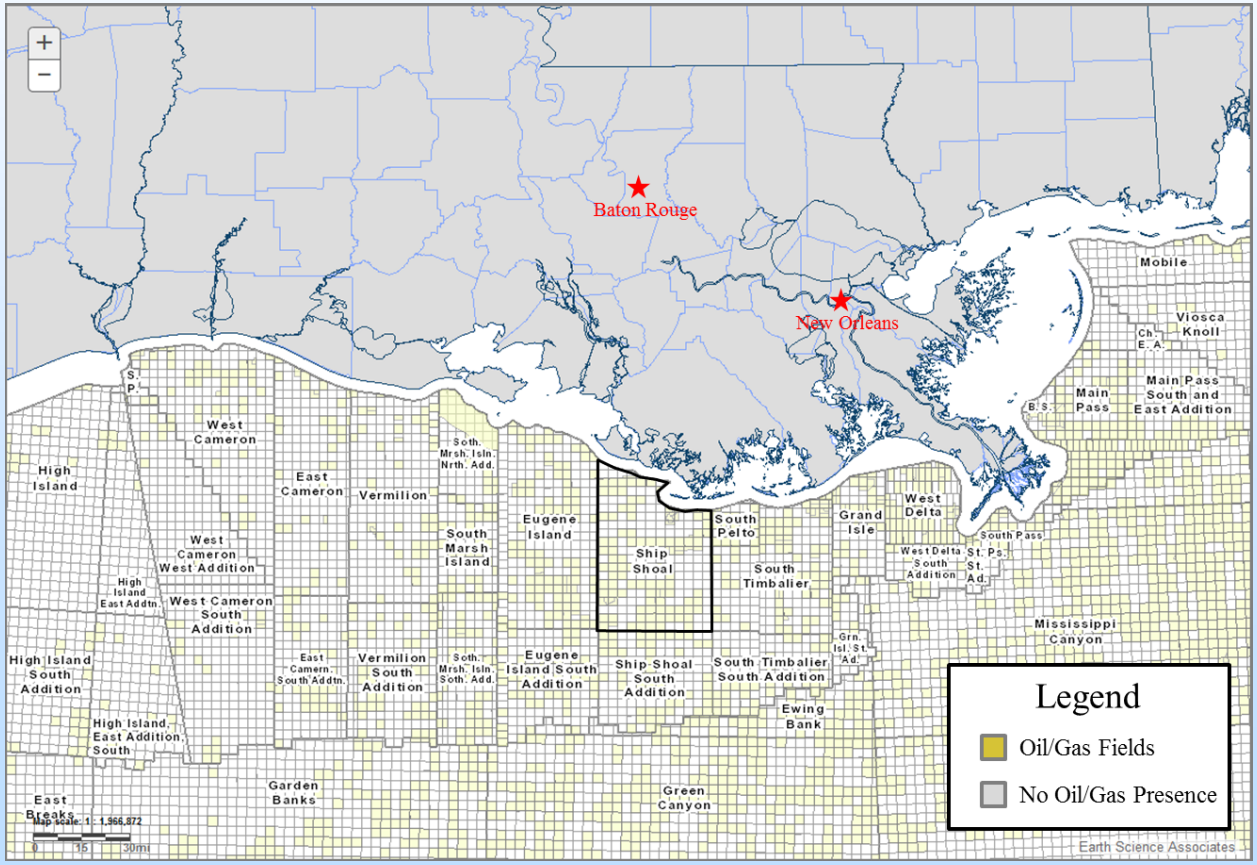
Background: Ship Shoal Area

The Ship Shoal area is located offshore Louisiana within the northern Gulf of Mexico.

Forty-seven oil and gas fields

- 32 active/ producing fields
- 15 expired/ depleted fields

Production occurs between 2,000 to 17,600 feet deep, from lower Pleistocene to Middle Miocene.

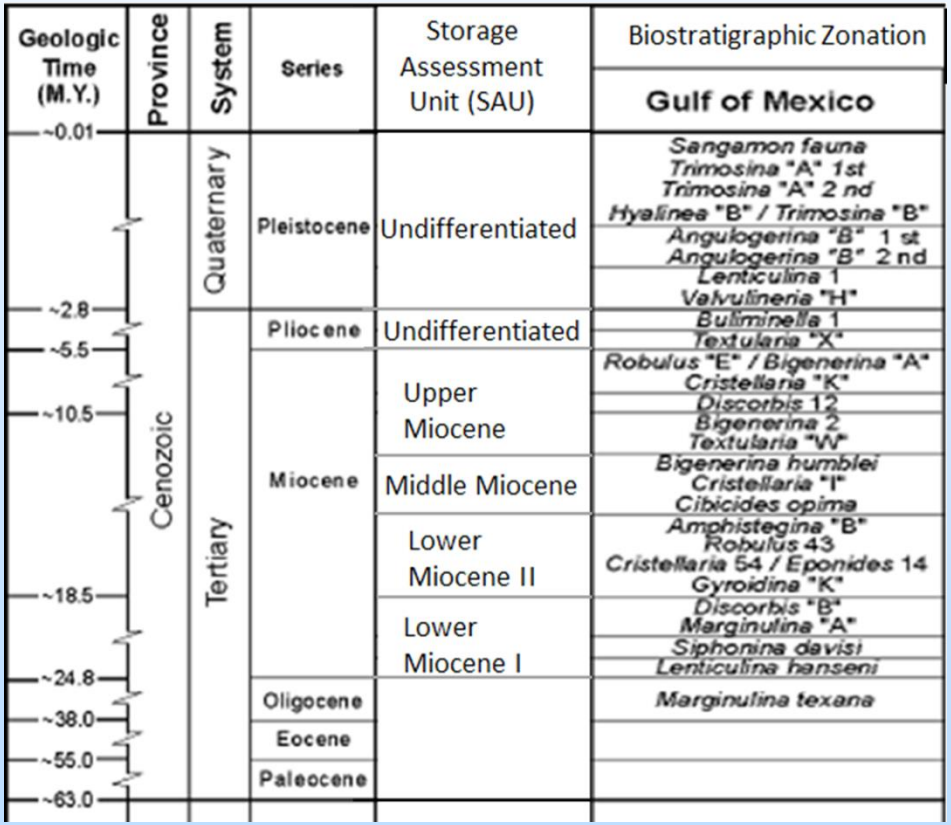


Modified from Earth Science Associates

Technical Status

Geologic Data Review

Biostratigraphic zonation and corresponding Storage Assessment Unit for Cenozoic in the Gulf of Mexico:



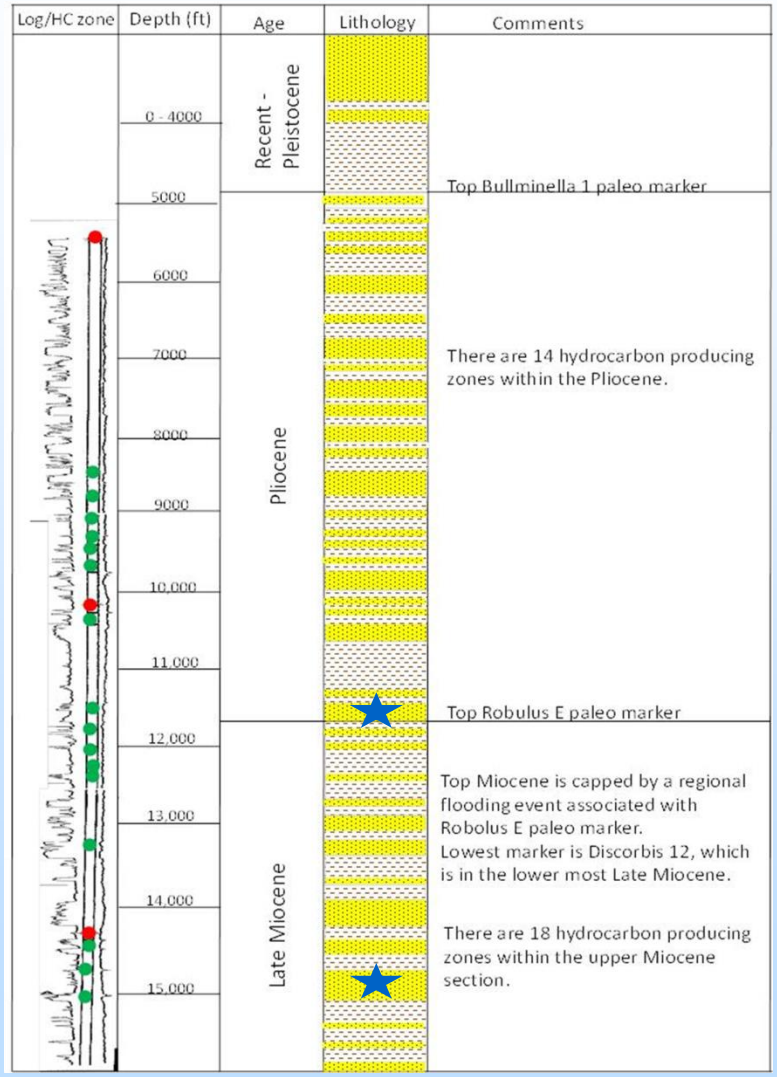
Geologic Time (M.Y.)	Province	System	Series	Storage Assessment Unit (SAU)	Biostratigraphic Zonation: Gulf of Mexico
~0.01	Cenozoic	Quaternary	Pleistocene	Undifferentiated	*Sangamon fauna* *Trimosina "A" 1st* *Trimosina "A" 2 nd* *Hyalinea "B" / Trimosina "B"*
					Angulogerina "B" 1 st *Angulogerina "B" 2 nd*
					Lenticulina 1 *Valvulineria "H"*
~2.8		Tertiary	Pliocene	Undifferentiated	*Buliminella 1*
					Textularia "X"
~5.5			Miocene	Upper Miocene	*Robulus "E" / Bigenerina "A"* *Cristellaria "K"*
					Discorbis 12
~10.5					*Bigenerina 2* *Textularia "W"*
				Middle Miocene	*Bigenerina humblei* *Cristellaria "I"* *Cibicides opima*
				Lower Miocene II	*Amphistegina "B"* *Robulus 43* *Cristellaria 54 / Eponides 14* *Gyroidina "K"*
~18.5				Lower Miocene I	*Discorbis "B"* *Marginulina "A"*
					Siphonina davisi
					Lenticulina hanseni
~24.8			Oligocene		*Marginulina texana*
~38.0			Eocene		
~55.0			Paleocene		
~63.0					

Technical Status

Geologic Data Review

Generalized stratigraphic column and type log for SS Block 107 field.

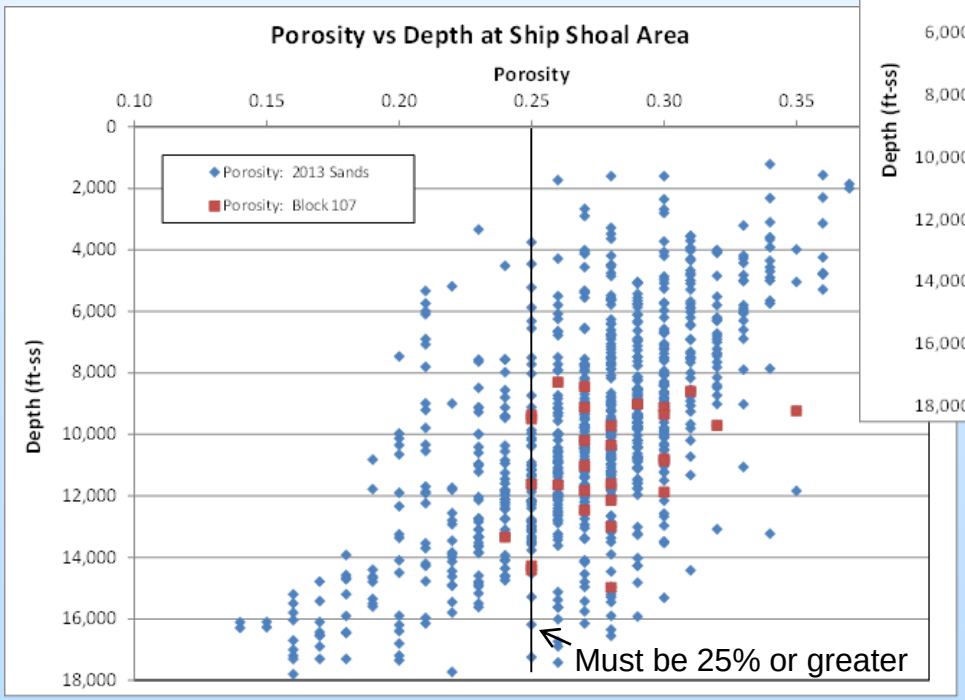
- Green dots indicate oil reservoirs, red dots are gas reservoirs.
- Blue stars indicate target injection zones.

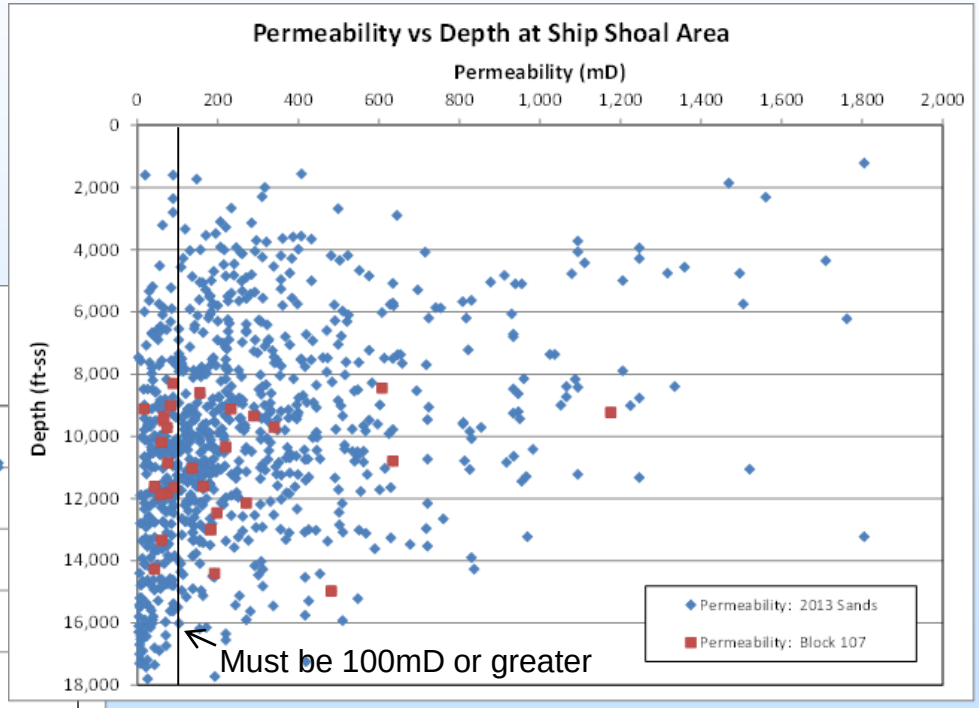


Technical Status

Geologic Data Review

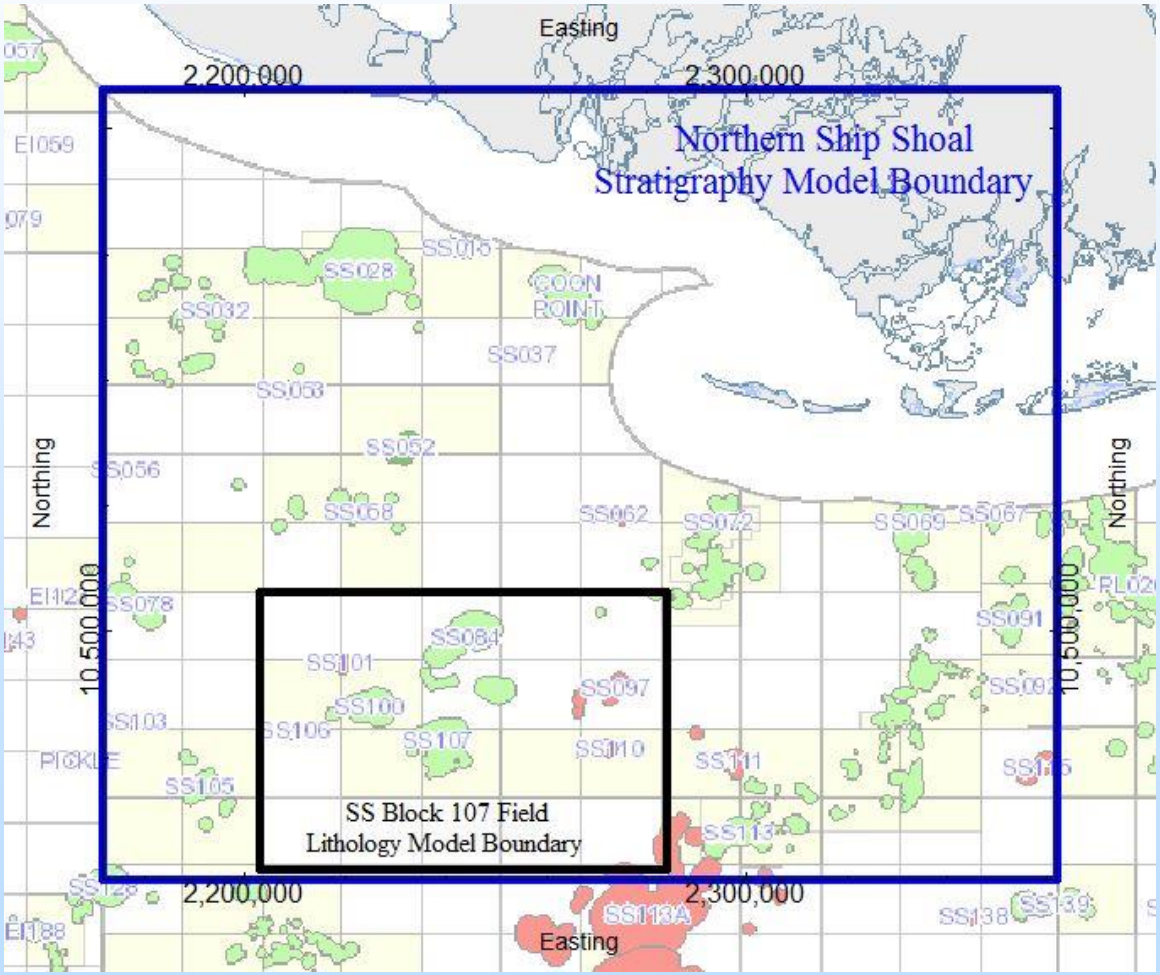
Porosity and permeability evaluation





Technical Status

Geologic Model Development

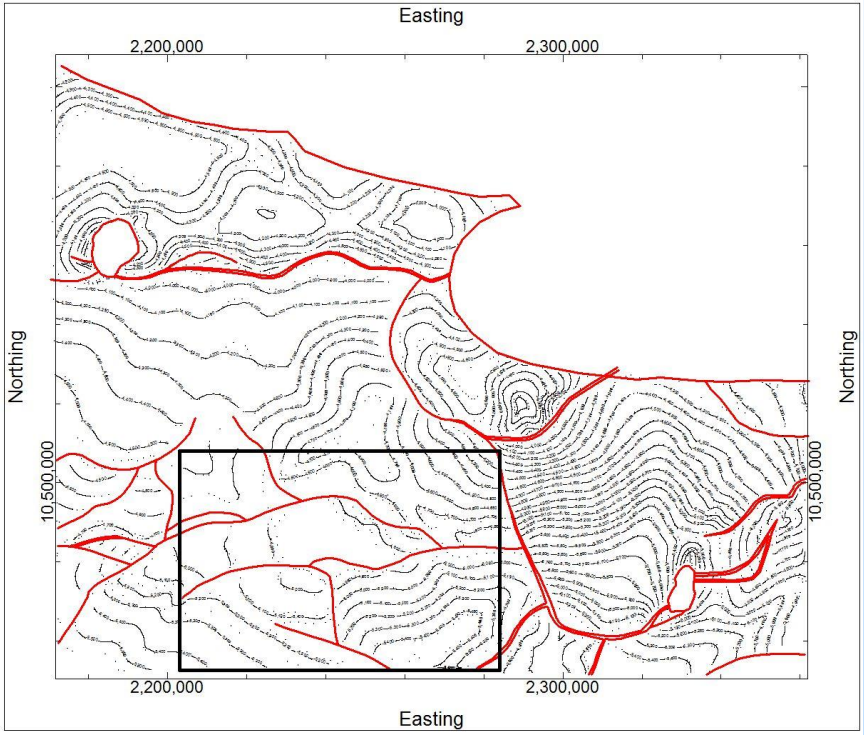


- Designate model domain
- Collect well data, horizon grids, and paleo info for Northern Ship Shoal area

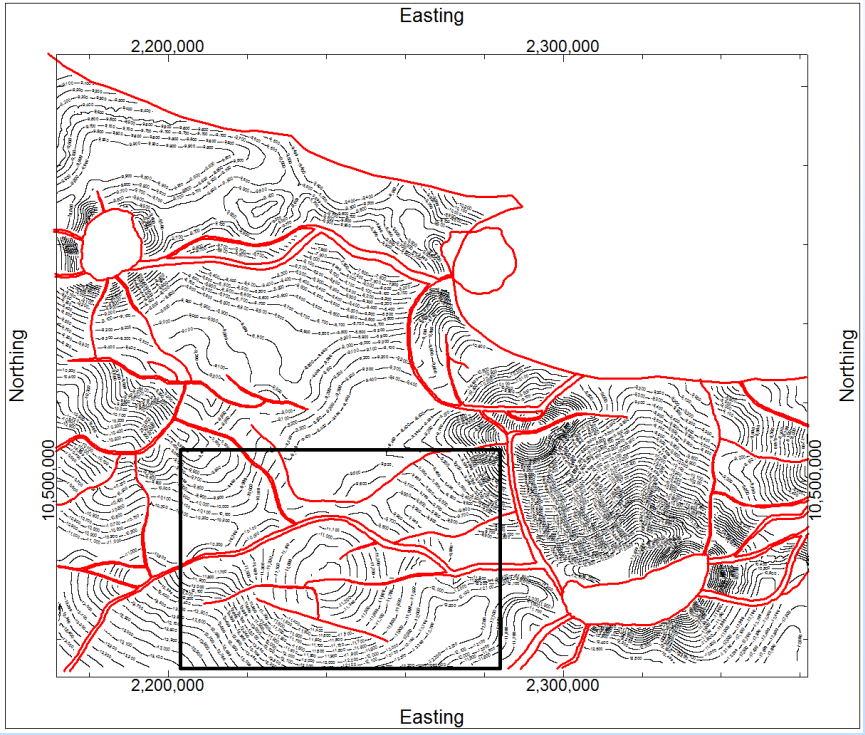
Technical Status

Geologic Model Development

Structure maps



Top Pliocene Bullminella 1 Horizon



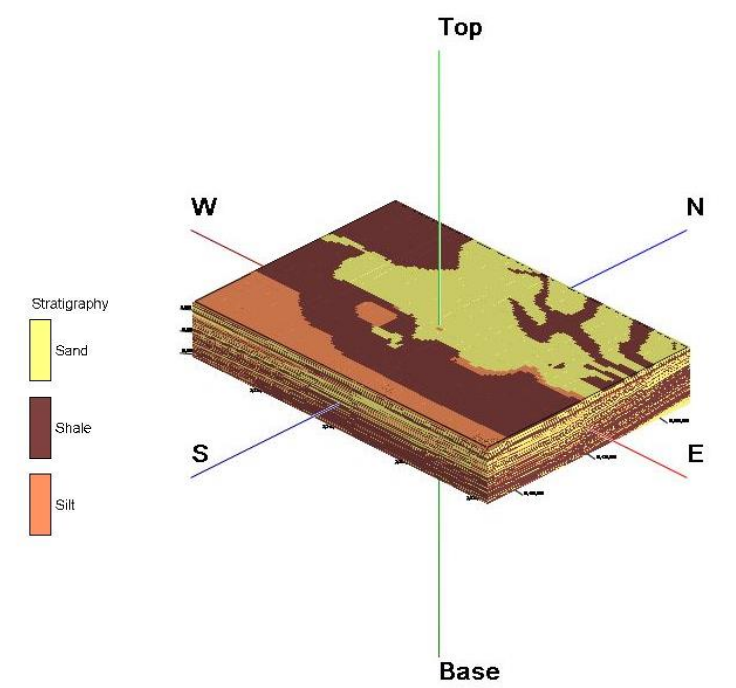
Top Miocene Robulus E Horizon

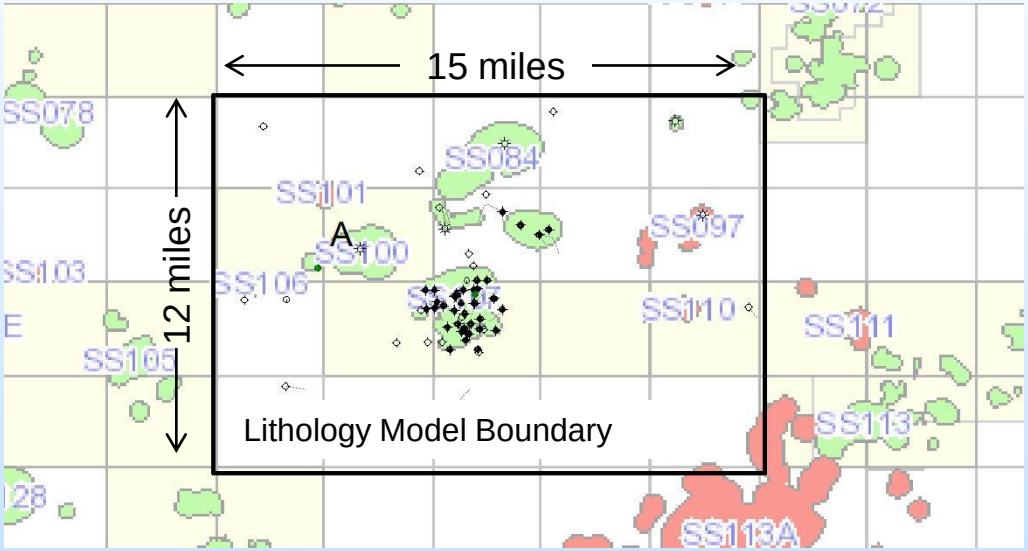
These maps were modified from work provided by IHS Interpreted Formation Tops products in the Gulf of Mexico.
Data sources: BOEM, GOMsmart, and IHS.

Technical Status

Geologic Model Development

Lithology model development for SS Block 107





Model contains 5.1 million cells

Cell spacing is 750ft x 750ft by 20ft

Technical Status

Storage Capacity Estimation

NETL approved CO2 Storage Resource Estimate:

$$G_{CO2} = A_t h_g \emptyset_{tot} \rho E_{saline}$$

Using BOEM reservoir data, the existing oil/gas fields in northern Ship Shoal have the potential to store:

P10= 12 million tons,

P50= 47 million tons, and

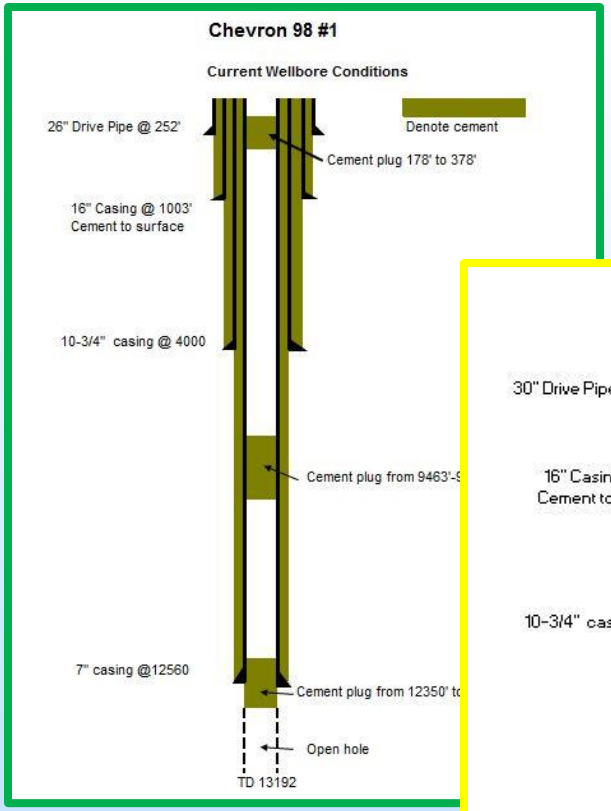
P90= 127 million tons of CO2

Technical Status

Risk Assessment

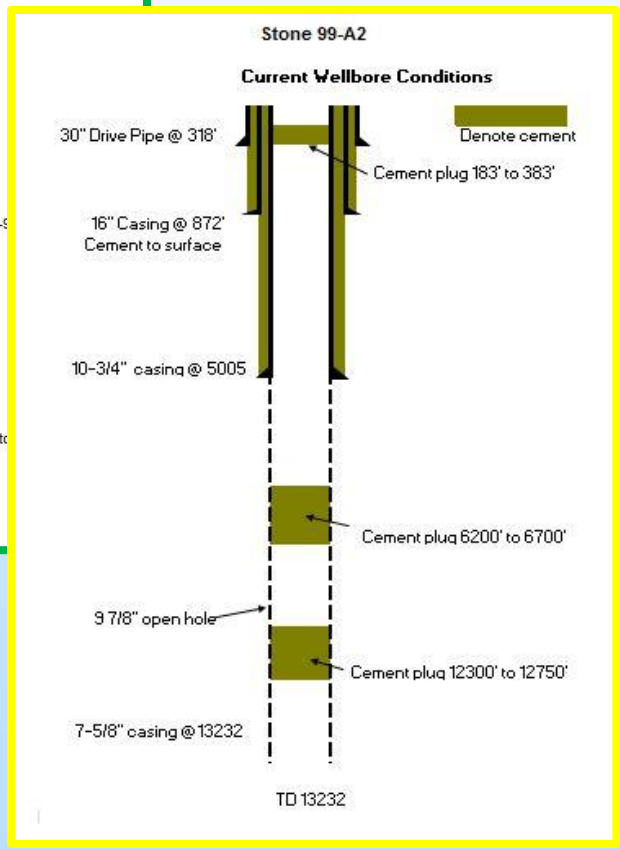
Well Integrity- 77 well schematics

Good Integrity		Moderate Integrity
Chevron 98-1	Energy XXI 108-13	Stone 99-A2
Stone 99-1	Energy XXI 108-14	Chevron 99-2
Stone 99-1 ST1	Energy XXI 108-15	Chevron 99-4
Stone 99-1 ST2	Energy XXI 108-16 ST1	Chevron 99-5
Stone 99-3	Energy XXI 108-17	Chevron 107-B1
Stone 99-A1	Energy XXI 108-19	Chevron 107-5
Stone 99-A1 ST1	Energy XXI 108-22	Energy XXI 108-1
Stone 99-A2ST1	Energy XXI 108-23	Energy XXI 108-2
Stone 99-E1	Energy XXI 108-24	Energy XXI 108-3
Stone 99-E2	Energy XXI 108-26	Energy XXI 108-4 ST1
Chevron 99-1	Energy XXI 108-29	Energy XXI 108-7
Chevron 99-3	Energy XXI 108-30	Energy XXI 108-18
Chevron 99-6	Energy XXI 108-31	Energy XXI 108-20
Chevron 99-7	Energy XXI 108-32	Energy XXI 108-21
Chevron 99-8	Energy XXI 108-33	Energy XXI 108-25
BoisDarc 107-1	Energy XXI 108-34	Energy XXI 108-27
Chevron 107-1	Energy XXI 108-34ST1	Energy XXI 108-28
Chevron 107-2	Energy XXI 108-36	Energy XXI 108-35
Chevron 107-3	Energy XXI 108-37	Energy XXI 108-40
Chevron 107-4	Energy XXI 108-38	
Chevron 107-6	Energy XXI 108-39	
Chevron 107-7	Energy XXI 108-41	
Energy XXI 108-5	Energy XXI 108-41ST1	
Energy XXI 108-6	Energy XXI 108-41ST2	
Energy XXI 108-8	Energy XXI 108-41ST2BP	
Energy XXI 108-9	Energy XXI 108-42	
Energy XXI 108-10	Energy XXI 108-42ST1	
Energy XXI 108-11	Energy XXI 108-43	
Energy XXI 108-12		



Good Integrity

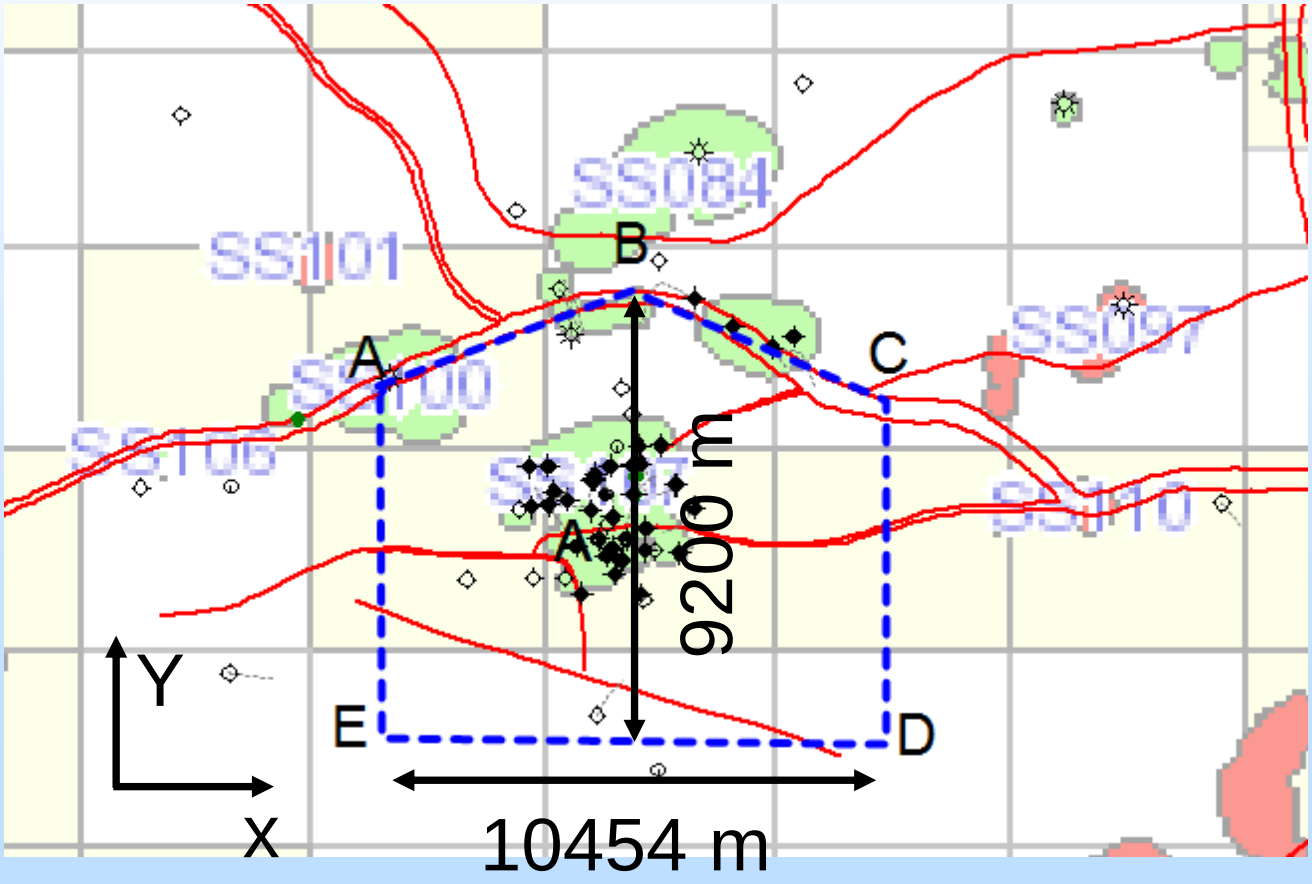
Moderate Integrity



Technical Status

Fluid Flow Model Development

Model Boundary

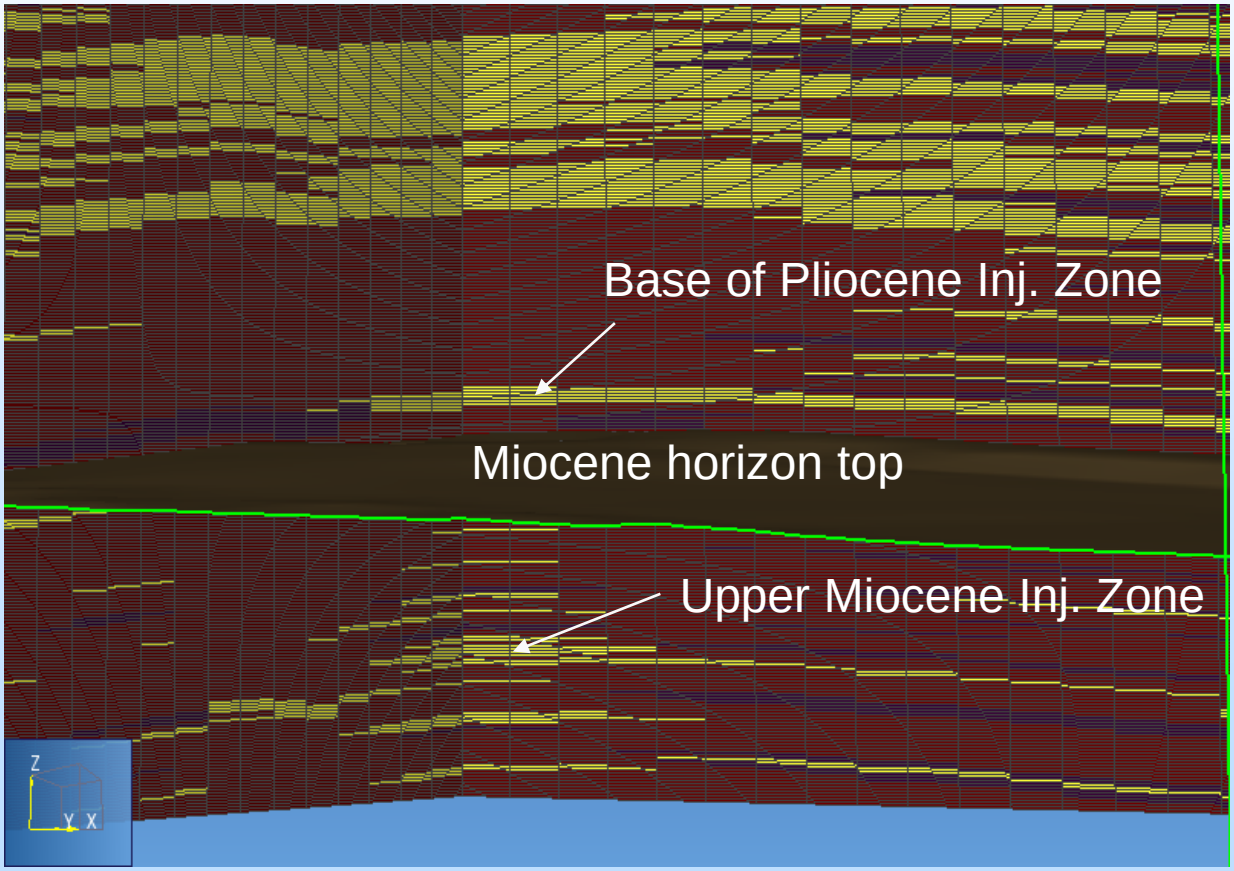


	Depth (ft)	Depth (m)
Z_{min}	-5000	-1524
Z_{max}	-15000	-4572

Technical Status

Fluid Flow Model Development

Injection Zone Selection



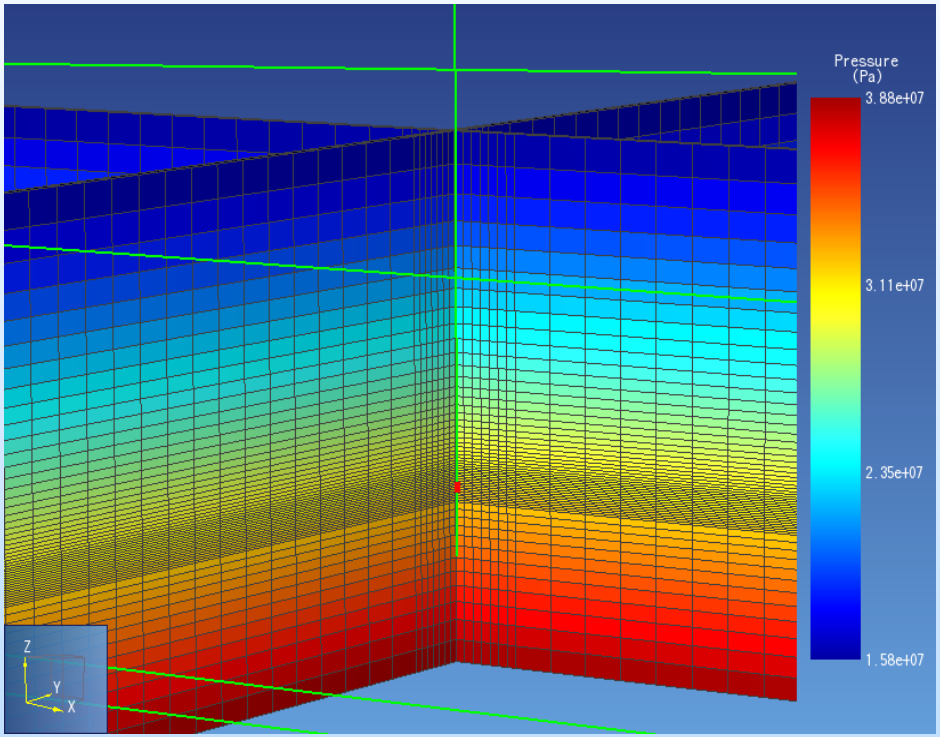
Target Injection Zones:

- Base of Pliocene
- Upper Miocene

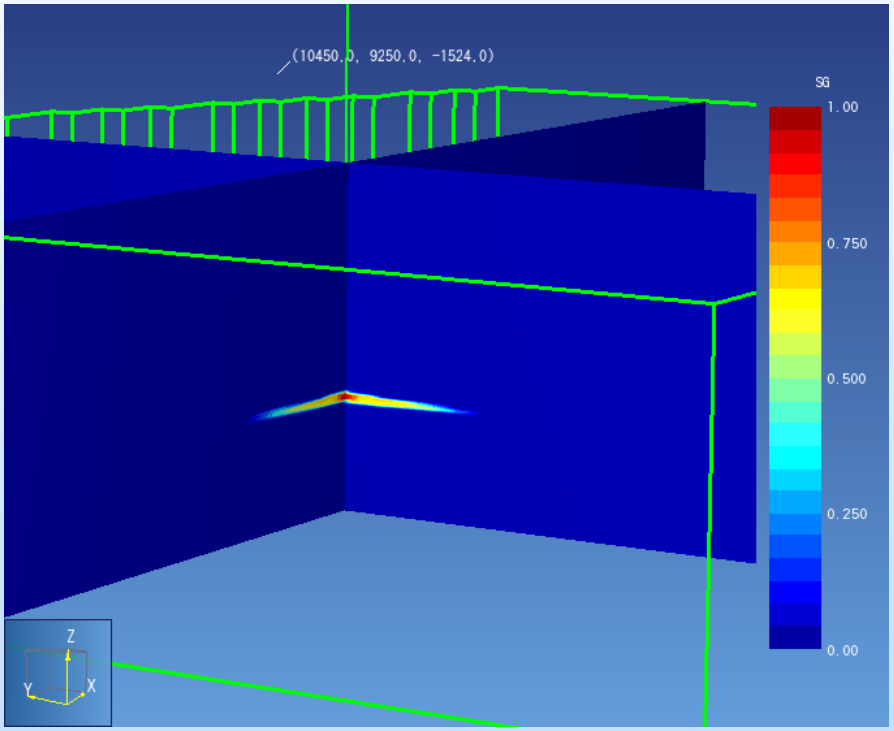
Technical Status

Fluid Flow Model Development

Initialization and Test Run Result for Base of Pliocene Model



Initialization of pressure distribution



Test run gas saturation result after 10 years of injection at a rate of 1 million ton/year

Accomplishments to Date

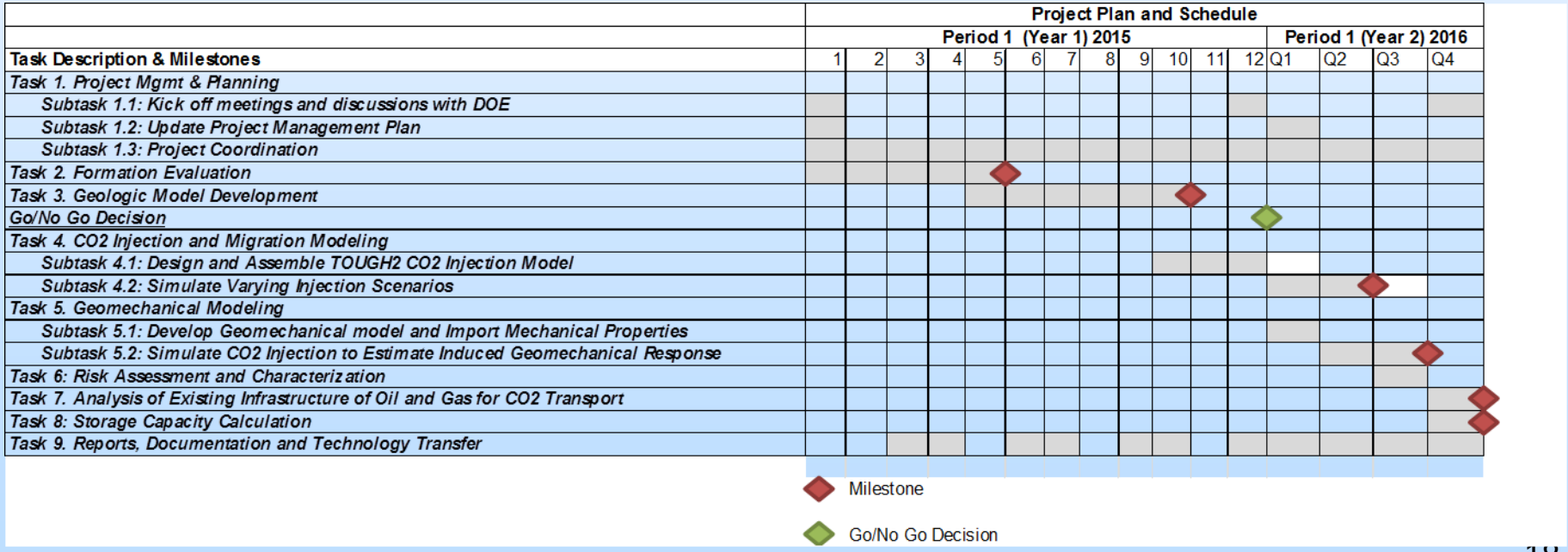
- Completed geologic data review and formation evaluation to identify targets and seals. Review indicated sufficient porosity and permeability for injection.
- Estimated that at P50, Ship Shoal area will contain approximately 47 million tons of CO2 storage capacity in depleted oil and gas reservoirs.
- Developed a geologic model of the Ship Shoal area, producing Pliocene and Miocene structure maps. Included detailed lithology model of the SS Block 107 field.
- Prepared a preliminary risk assessment by evaluating well integrity for all wells within SS Block 107 field. Identified wells with good and moderate integrity.
- Began fluid flow model development.

Phase II Work Program

Met all criteria and submitted Go-No Go Decision Report

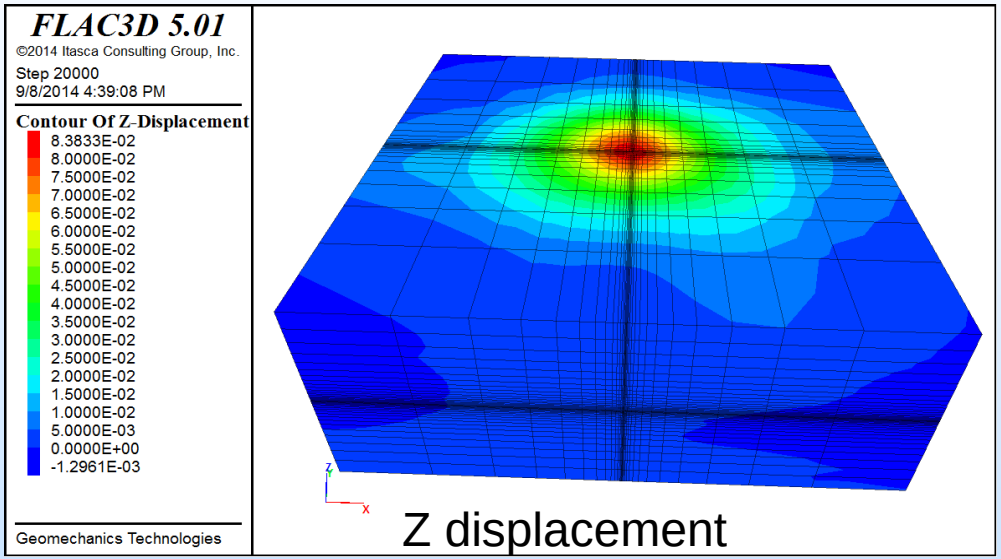
Submitted Continuation Plan:

- CO2 Migration modeling
- Geomechanical modeling
- Risk assessment
- CO2 transport
- Refined storage capacity estimation

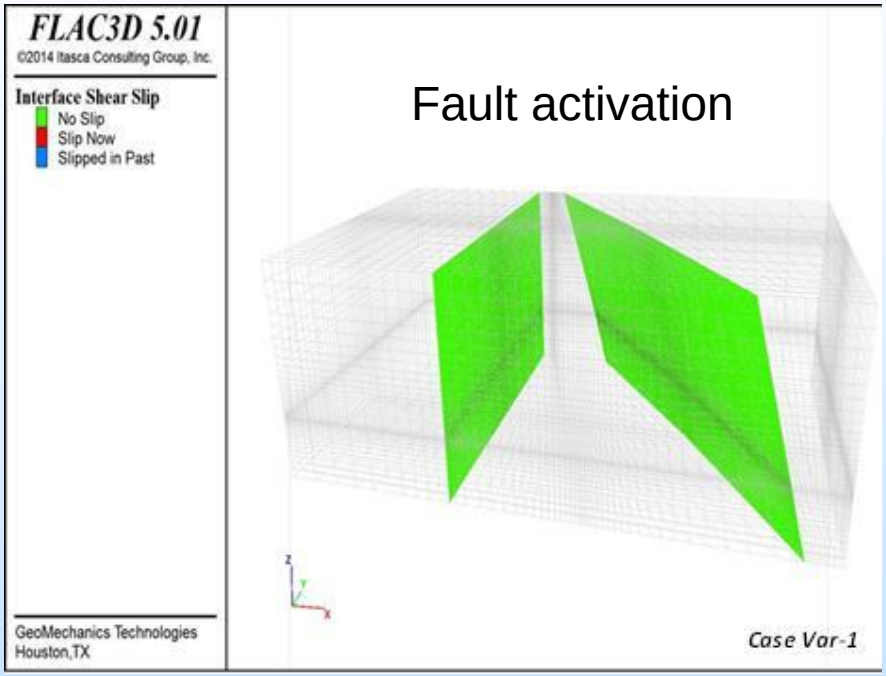


Phase II Work Program

Geomechanical modeling



Z displacement



Based on pressure distribution from fluid flow simulation, geomechanical modelling will estimate the stress change due to pressure change, thus evaluate the corresponding z displacement and fault activation risk.

Synergy Opportunities

Our work is complementary to the offshore Gulf of Mexico work (east of our study site) performed by UT Austin; a comparison of estimated storage for oil and natural gas reservoirs would be beneficial. At the conclusion of Phase II, it would be interesting to learn how evaluating regional saline formations increased their estimated capacity and review with them how our fluid flow and geomechanical modeling affected our capacity estimations.

Summary

- GeoMechanics Technologies have completed a detailed geological characterization of the SS Block 107 field and its surrounding area.
- Results thus far indicate high confidence that Miocene and Pliocene targets and seals are sufficient to store at least 30 million tons of CO2 within the Ship Shoal area.
- Phase II will include CO2 migration and geomechanical modeling, detailed risk assessment, pipeline analysis for CO2 transport, and a refined storage capacity estimation.

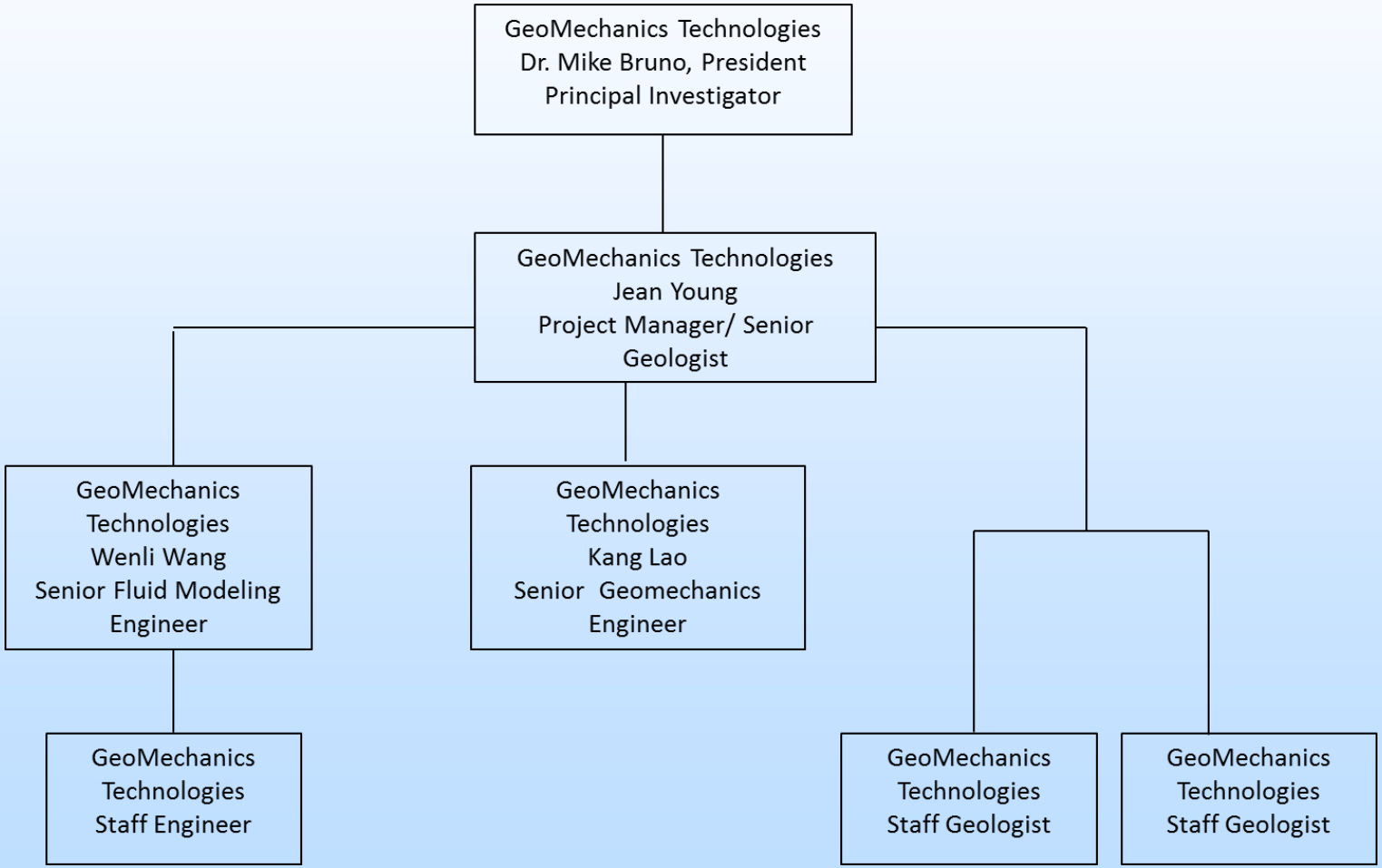
Appendix

– Organization Chart

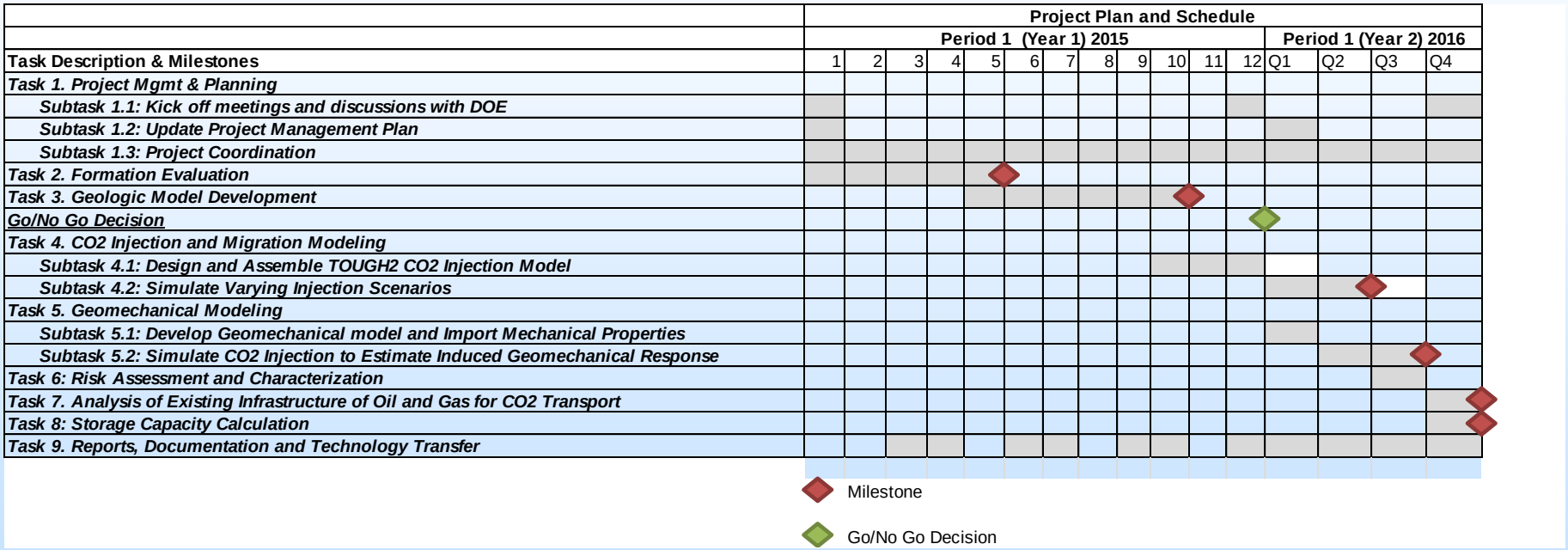
– Gantt Chart

– Bibliography

Organization Chart



Gantt Chart



*currently near the end of Period 1 with all work accomplished until month 11

Bibliography

Lao, K., 2016, Assessment of CO2 Storage Resources in Depleted Oil and Gas Fields in the Ship Shoal Area, Gulf of Mexico, International Workshop on Offshore Geologic CO2 Storage, Austin, Texas