Preliminary evaluation of offshore transport and storage of CO2

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Phase III 15.1 and 15.2

Preliminary Evaluation of Offshore Transport and Storage of CO_2

Prepared for:
Southeast Regional Carbon Sequestration Partnership
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by

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Task 15 – NATCARB Atlas Update – CO_2 Sequestration Capacity Offshore Gulf of Mexico

November 2010

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Introduction

As part of SECARB Phase III "Early" Test, Task 15, the Gulf Coast Carbon Center at The University of Texas Bureau of Economic Geology compiled and mapped initial resource data. The area of interest encompassed the western portions of the offshore Gulf of Mexico (GOM) that is under Federal jurisdiction (Bureau of Ocean Energy Management, Regulation and Enforcement "BOEMRE"; formerly MMS) and adjacent state waters of Louisiana and Mississippi. The study refined a previous assessment of the capacity of selected potential storage targets and inventoried existing infrastructure such as pipelines and wells. Data from potential storage targets and existing infrastructure will feed into planned studies of regulatory requirements for the potential of re-using existing wells for carbon dioxide injection and long-term sequestration. The mapping information will be incorporated into the SECARB regional data base and will be made available for incorporation into the next NATCARB ATLAS update.

Deliverables

PHI-h Maps (*gross pore-space* x *thickness* – roughly equivalent to capacity for sequestering CO_2) were prepared for the following major sandstone-bearing units, which we informally call Geologic Sequestration Units (GSU) in the offshore northwestern GOM:

Figure 1. Upper Pliocene GSU
Figure 2. Lower Pliocene GSU
Figure 3. Upper Miocene GSU
Figure 4. Lower Miocene GSU
Figure 5. Oligocene GSU

We did not include the Pleistocene because most of it occurs beyond the present-day shelf edge in deep water. Likewise, units older/beneath the Oligocene are too deeply buried (>15000 ft) and/or lie in deep water (>1000 ft), and/or are located too far from shore-based sources to be considered, at present, as CO_2 sequestration targets.

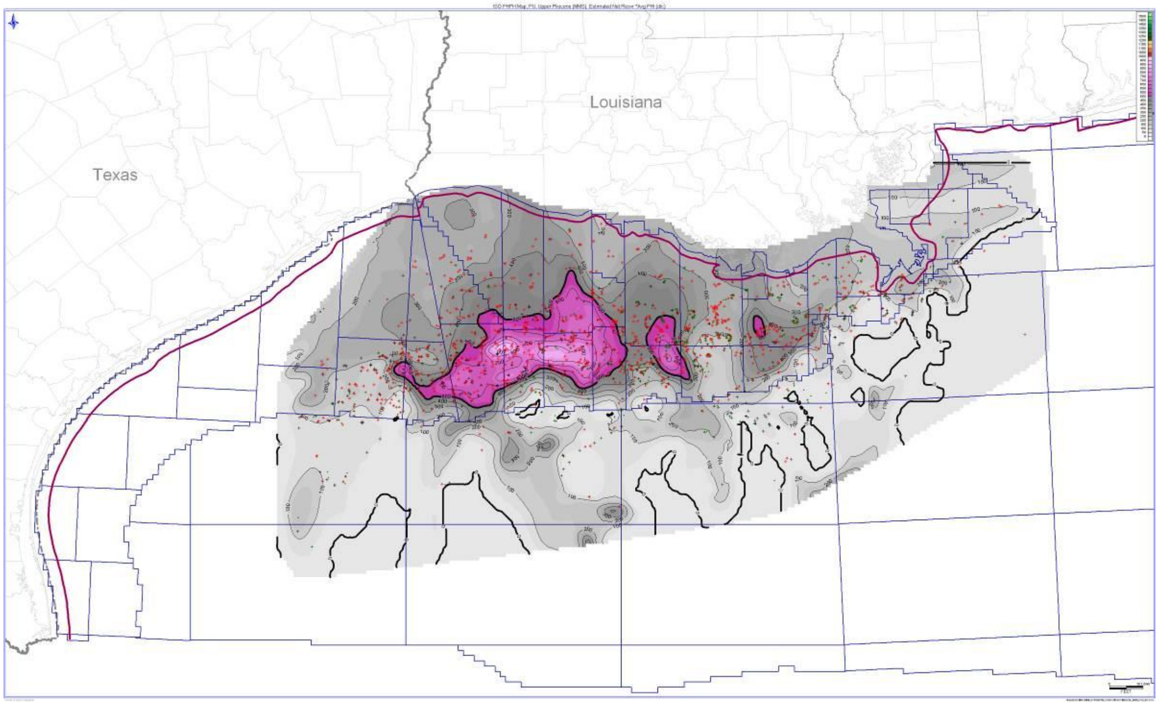

Figure 1. Upper Pliocene Geologic Sequestration Unit, PHI-h Map

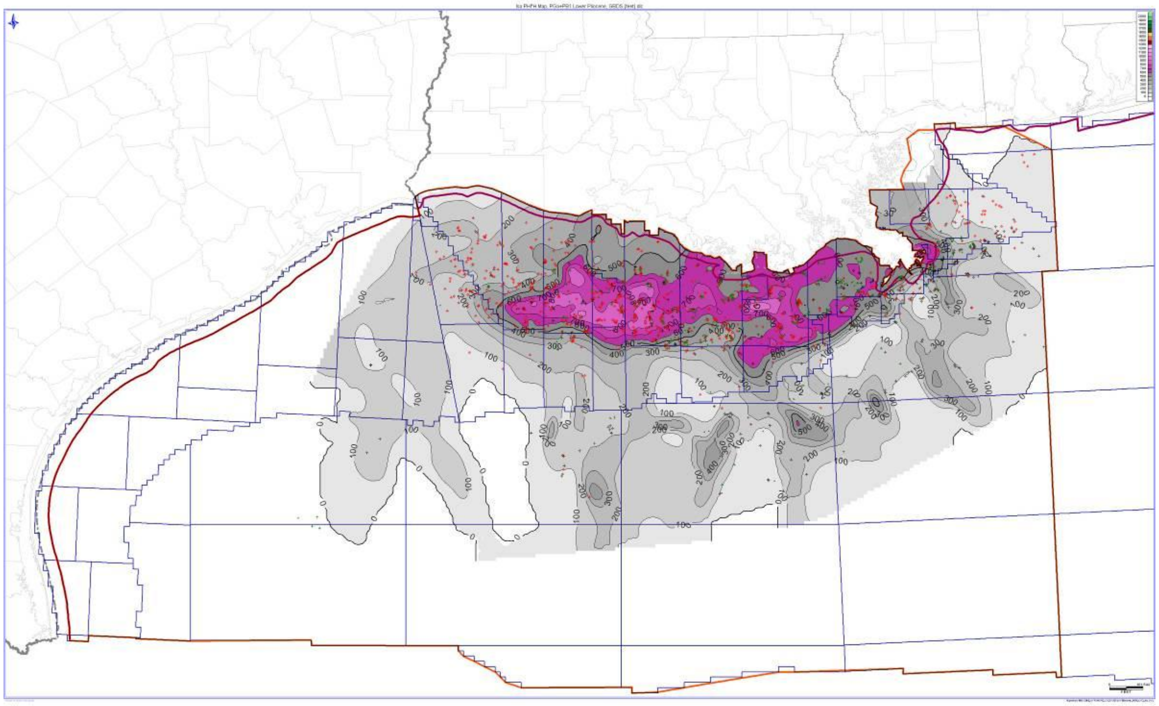

Figure 2. Lower Pliocene Geologic Sequestration Unit, PHI-h Map

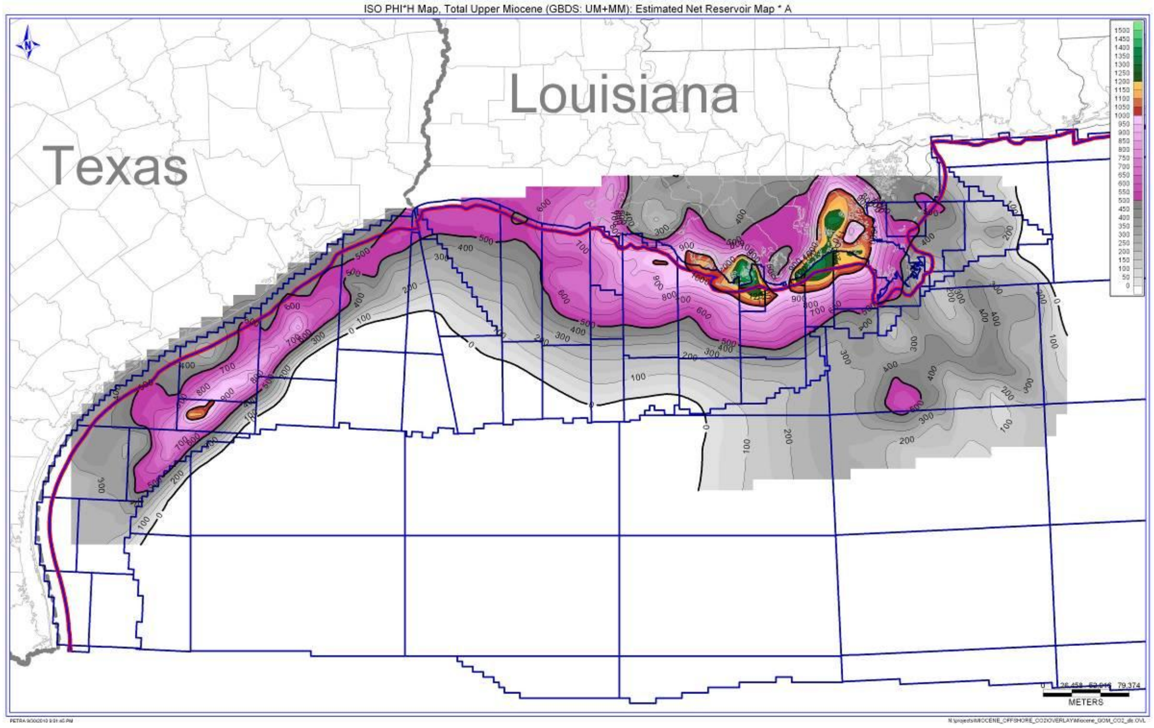

Figure 3. Upper Miocene Geologic Sequestration Unit, PHI-h Map

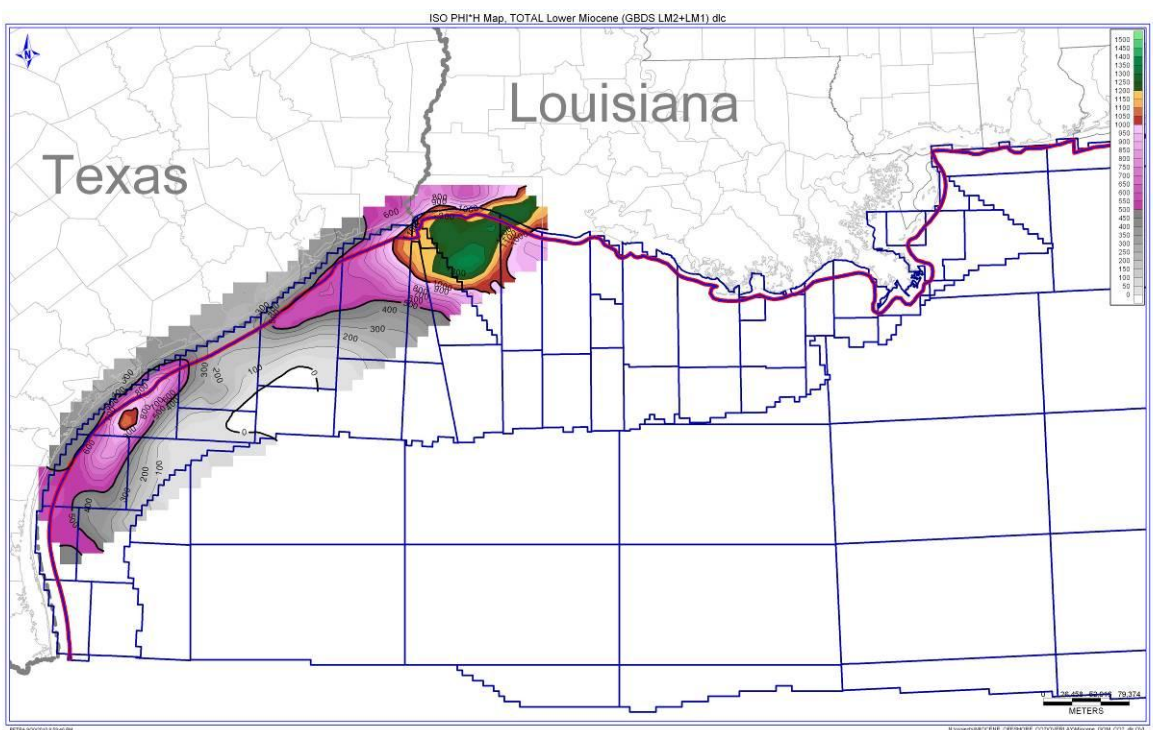

Figure 4. Lower Miocene Geologic Sequestration Unit, PHI-h Map

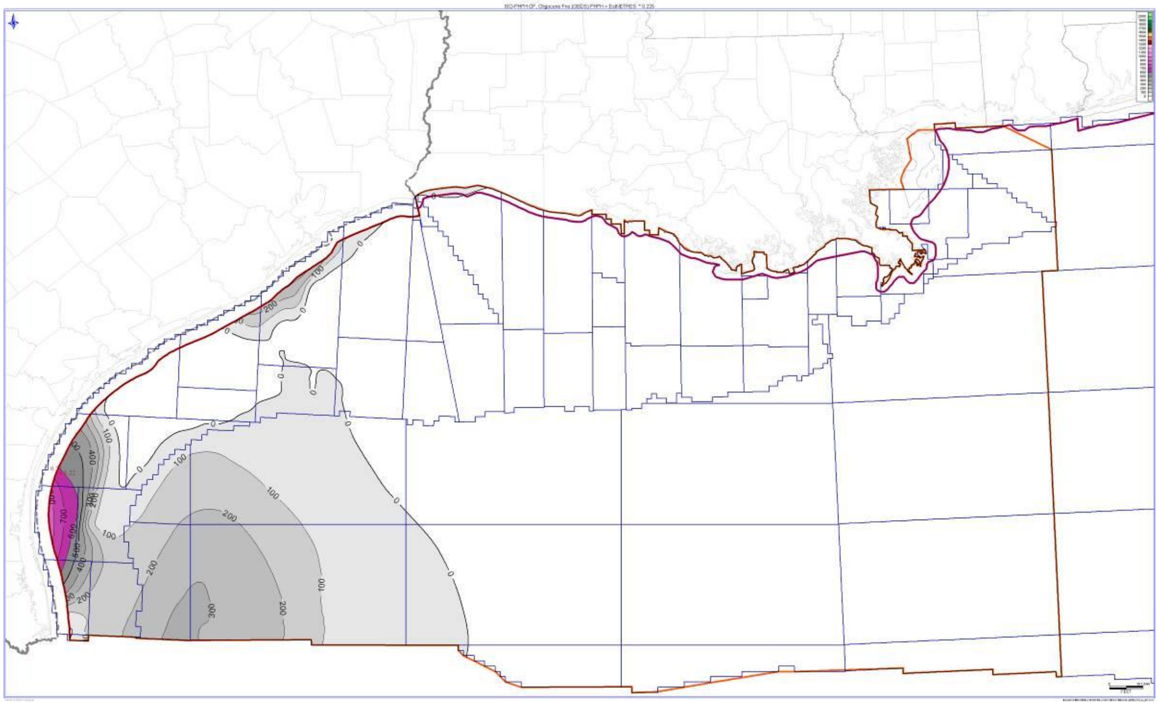

Figure 5. Oligocene Geologic Sequestration Unit, PHI-h Map

Source Data and Technical Procedures

Source Data

Well Control.--All readily available basic well data, including header information, total depth, and latitude-longitude locations from more than 57,000 wells in the GOM Federal OCS and adjacent state waters of Louisiana and Mississippi were obtained from Bureau of Ocean Energy Management, Regulation and Enforcement ("BOEMRE"; formerly MMS) and IHS Energy (Fig. 6). This information was provided in digital formats and was loaded into IHS' Petra PC-based subsurface analysis software application.

Sandstone Isopach Maps.--Sandstone-bearing interval isopach maps were obtained from The University of Texas at Austin Institute for Geophysics Gulf Basin Depositional Synthesis project ("GBDS"). The GBDS maps were transferred to the Gulf Coast Carbon Center (GCCC) in the form of digital GIS layers and these were imported into our Petra workstation. Over the last 15 years, the GBDS team, led by Dr. William Galloway, has integrated well, seismic, and published scientific data to develop a comprehensive interpretation of Cenozoic depositional systems in the GOM Basin. The project team has identified and mapped successive Cenozoic sedimentary supply and cross-slope transport axes to help guide petroleum reservoir prediction. More information on GBDS is located at http://www.ig.utexas.edu/research/projects/gbds/gbds.htm.

Paleontology and Reservoir Porosity.--BOEMRE's website provided digital files of paleontologic (paleo) reports (17,885 wells; Fig. 7) and reservoir properties information, including porosity (10,601 wells; Fig. 8) that were also loaded into the Petra workstation. BOEMRE's paleo reports was also the basis for GBDS' stratigraphic mapping intervals. Thus, the GBDS sandstone interval maps and BOEMRE-derived reservoir and porosity maps represent independent data sets that were combined on the basis of an internally consistent methodology.

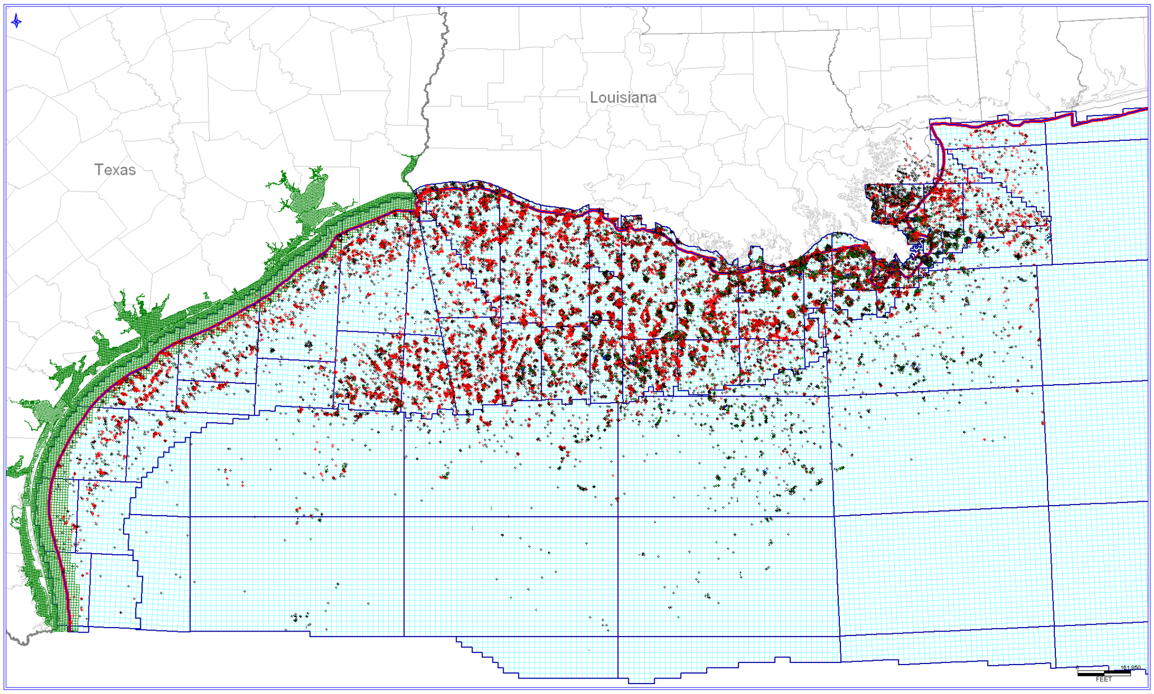

Figure 6. Total wells (57, 243) used in project. Sourced from IHS Energy and BOEMRE (MMS).

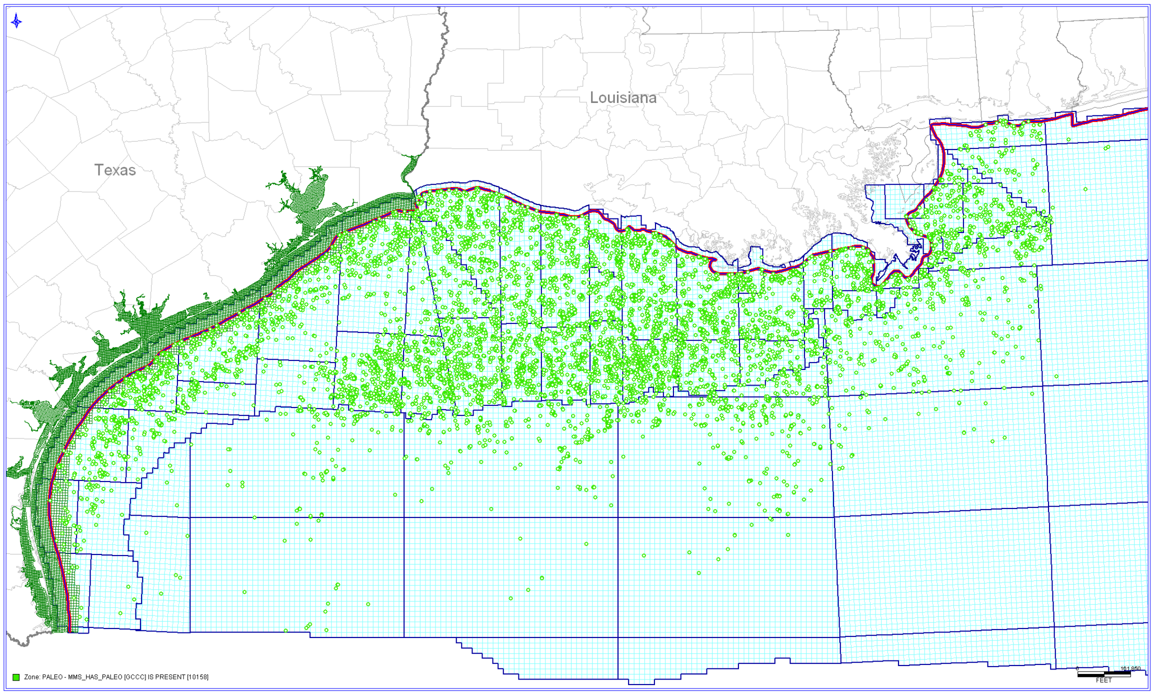

Figure 7. BOEMRE (MMS) Paleontologic reports available for Pleistocene-Oligocene stratigraphic intervals (17,885 wells).

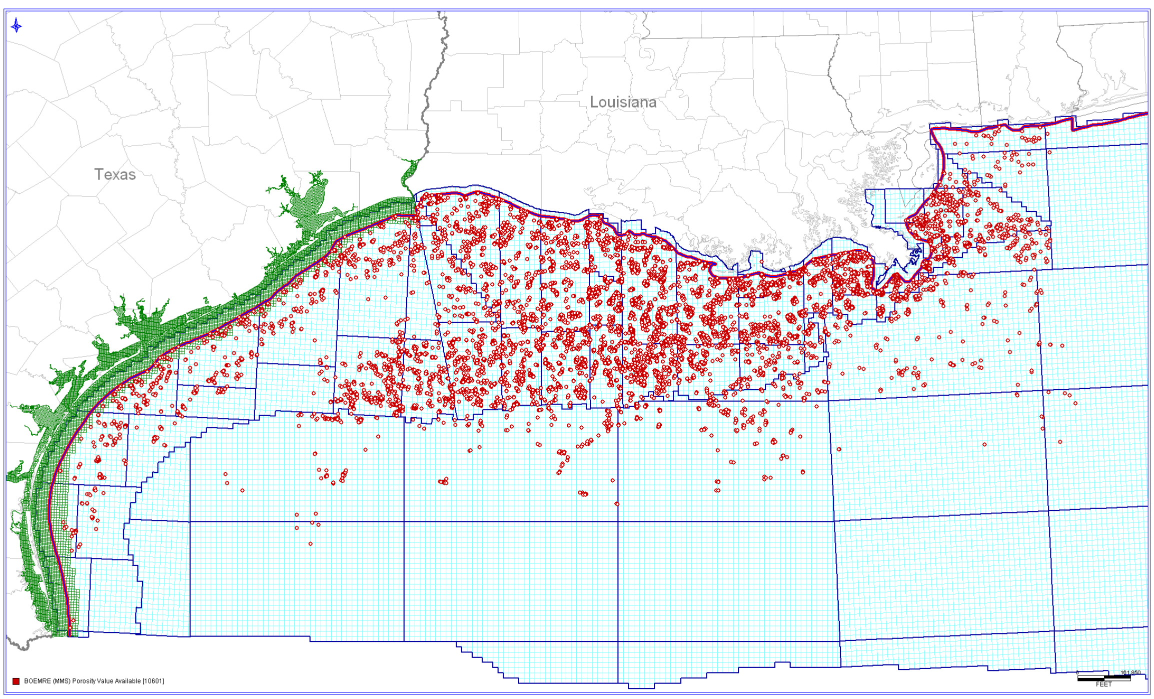

Figure 8. BOEMRE (MMS) Porosity data available for Pleistocene-Oligocene stratigraphic intervals (10,601 wells).

Pipelines.— In order to provide an inventory of existing pipelines infrastructure the map in figure 9 was generated from data provided on BOEMRE's website. The map shows offshore GOM pipelines and their, respective, statuses. As detailed on the map, the majority of existing pipelines are either active oil (black color on the map) or active gas (green color on the map) pipelines, and they are mostly located along the northern GOM . There are also a significant number of out of service or abandoned pipelines (in gray). The map Key in figure 9 lists the pipeline categories that are most common in the BOEMRE database. See Table 1 for category percentages. Table 2 includes a complete list of all categories for the 11,755 total pipeline entries in the database file.

Table 1. Most common pipeline categories, number of pipelines per category and percentage of total per category.

Pipeline Type	#	%
Active Gas	359	3.1
Active Oil	3876	33.0
Active Other	1817	15.5
Proposed Gas	324	2.8
Proposed Oil	79	0.7
Abandoned	26	0.2
Out-of-Service Oil	3053	26.0
Out-of-Service Gas	1109	9.4
Other	1112	9.5

Table 2. List of all categories in the BOEMRE database - 11,755 total pipeline entries in the database file.

1. Active Gas Pipeline
2. Abandoned Pipeline
3. Active Gas/H2S Pipeline
4. Active Oil Pipeline
5. Out-of-Service Gas Pipeline
6. Out-of-Service Gas/H2S Pipeline
7. Out-of-Service Oil Pipeline
8. Out-of-Service Oil/H2S Pipeline
9. Out-of-Service Other Pipeline
10. Proposed Gas Pipeline
11. Proposed Gas/H2S Pipeline
12. Proposed Oil Pipeline
13. Proposed Other Pipeline
    Unidentified Pipeline

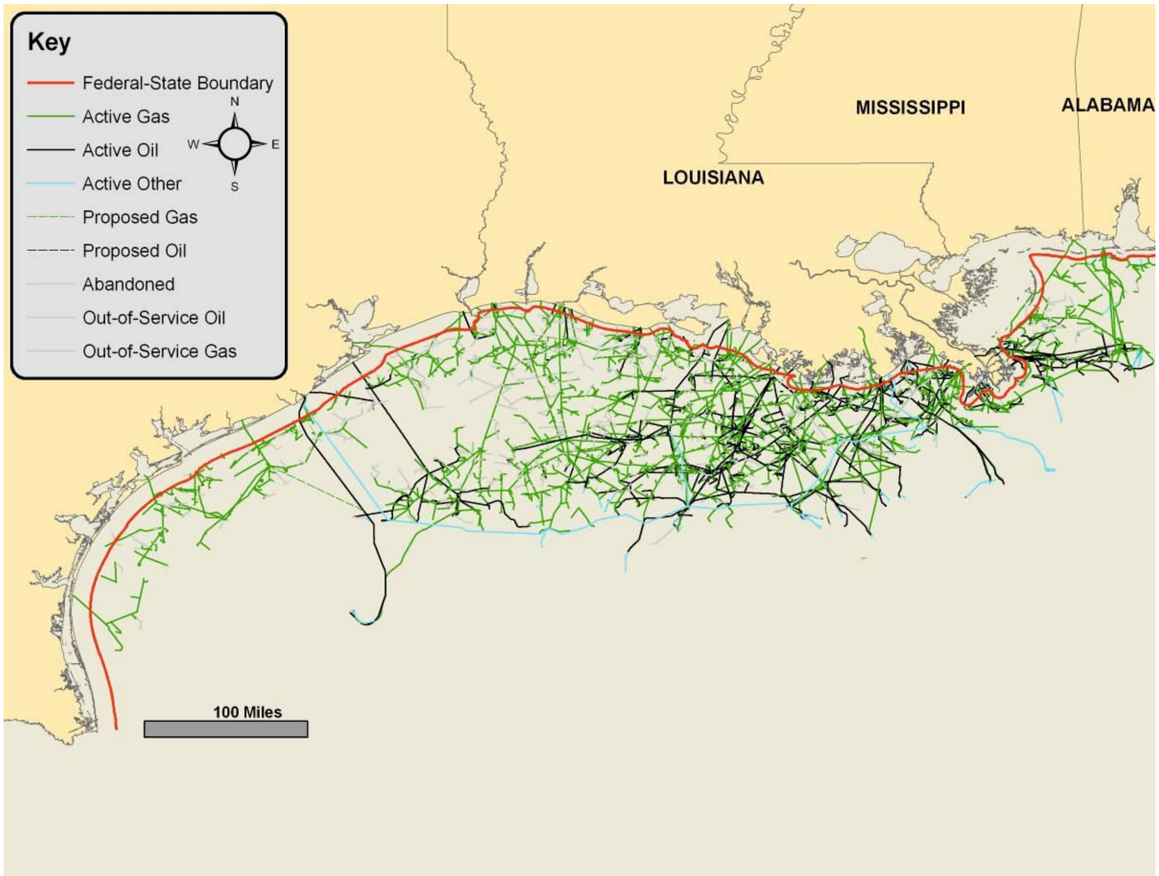

Figure 9. Locations and statuses (see Key) of offshore northwestern Gulf of Mexico pipelines from BOEMRE (MMS)

Technical Procedures

The technical procedure involved digitally compiling the data cited above in Petra and filtering, gridding and contouring the appropriate sandstone reservoir thickness and porosity information and then combining them to create the results. The specific equivalences that resulted in our Geologic Sequestration Units (BEG-GCCC GSU's) are shown in Figure 10.

SERIES	GBDS	Benthic Micro Fossil Zones (tops)	BOEMRE (formerly MMS)		BEG-GCCC MAPS, v3 (2010)			
	Genetic Sequence		CHRONOZONE	DESCRIPTION	Structure	Net Sand	Avg Porosity	Geol. Seq. Unit (GSU)
Pliocene	PAB + PL1	Angulogerina B / Calcidiscus macintyrei	PU	Upper Pliocene	top PAB	PAB + PL1	PU	Upper Pliocene
	PGa + PB1	Globorotalia altispira	PL	Lower Pliocene		PGa + PB1	PL	Lower Pliocene
Miocene	UM	Robulus E / Bigenerina A	MUU	Upper Upper Miocene	top MUU	UM + MM	MUU + MLU + MUM + MMM	Upper Miocene
			MLU	Lower Upper Miocene				
	MM		MUM	Upper Middle Miocene				
			MMM	Middle Middle Miocene				
	LM2	Amphistegina B	MLM	Lower Middle Miocene		LM2 + LM1	MLM + MUL + MML + MLL	Lower Miocene
			MUL	Upper Lower Miocene				
	LM1		MML	Middle Lower Miocene				
			MLL	Lower Lower Miocene				
Oligocene	OF	Heterosegina Sp.	OU	Upper Oligocene	top OF	OF	OU + OL	Oligocene
			OL	Lower Oligocene				

Figure 10. Correlation/combination chart showing how our (BEG-GCCC) GSU's (far right) were constructed from BOEMRE (MMS) chronozones and GBDS stratigraphic mapping units.

Individual GBDS maps are proprietary (available only to members of the consortium) and are thus not shown. In order to protect the proprietary nature of the GBDS maps, the five GSU's are an amalgamation of nine GBDS sandstone-bearing interval isopach maps. Likewise, BOEMRE (MMS) reservoir property data for ten chronozones were similarly combined from into the five GSU's.

Our specific workflow was as follows:

(1) Gathered 'sandstone-bearing interval' isopach maps from GBDS, imported to Petra and gridded/contoured each GBDS genetic sequence. "Sandstone bearing interval" represents intervals identified by GBDS to contain significant beds of sandstone within a larger interval (but smaller than total interval isopach; see Fig. 11):

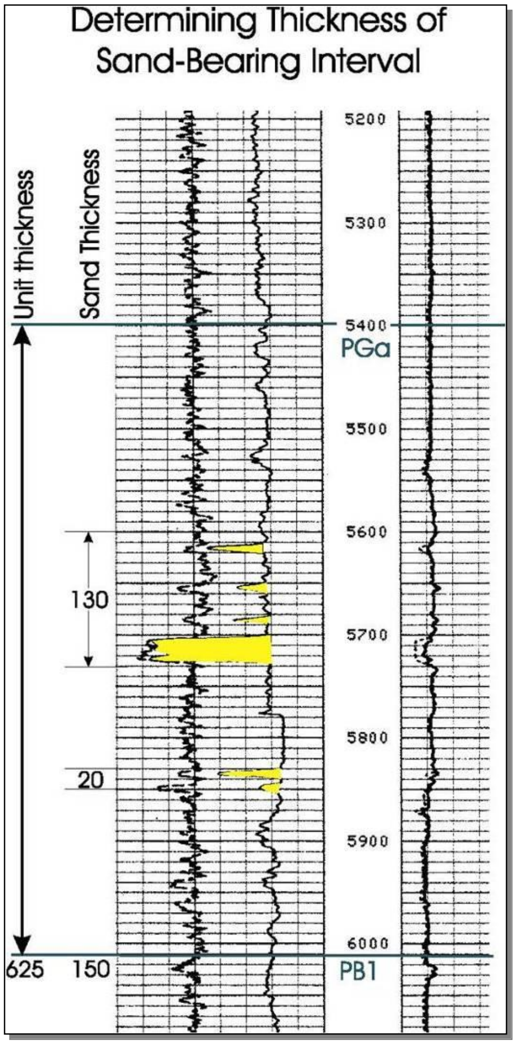

Figure 11. GBDS definition of "Sandstone bearing interval" (figure courtesy of Patty Ganey-Curry, UTIG-GBDS)

(2) Combined individual GBDS isopach maps into five larger GSU's. This was accomplished by summing the sandstone-bearing interval isopach grids for GBDS genetic sequences as shown in the "Net Sand" column of Figure 9.
(3) Created Net Sandstone Reservoir isopach maps by multiplying by 0.5 each sandstone-bearing interval isopach grid. (Assumption is that the average thickness of net, permeable sandstone reservoir makes up about 50% of the footages of the GBDS sandstone bearing intervals.)
(4) Filtered average reservoir porosity values (BOEMRE data) for, respective, MMS stratigraphic intervals (Fig. 9) and gridded and contoured each. Calculated average porosity for the (larger) GSU's by using 'grid-math' averaging functionality to determine average porosity of multiple MMS chronozone porosity grids.
(5) After Net Sandstone Reservoir and Average Porosity isopach maps had been completed for each GSU, the, respective, porosity (PHI) and net sandstone thickness (h) grids were multiplied together to determine the resulting PHI-h maps (Figures 1, 2, 3, 4 and 5).

The PHI-h Maps created as results for the NATCARB Atlas update do not represent CO_2 capacity maps per se, however they represent the fundamental basis for such subsequent capacity estimation. Capacity could be estimated by multiplying the PHI-h grids by a gridded map of CO_2 density (pressure and temperature dependent) and then by multiplying that product by an "efficiency factor", typically 1-4%.

Discussion of Results:

The Miocene has by far the best overall CO_2 capacity potential. Geographically, Louisiana has excellent potential for large Miocene capacities (Figures 3 and 4), and Texas has very good potential for large Miocene capacities. There is good Pliocene potential in offshore Louisiana (Figures 1 and 2), particularly in the Lower Pliocene (Figure 2). Some fair Oligocene capacity appears to be available offshore of South Texas (Figure 5).