




**Characterization of the Offshore Wilmington Graben  
For Large-Scale CO<sub>2</sub> Sequestration**



Presented to WESTCARB 2010 Annual Business Mtg  
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Terralog Technologies USA, Inc  
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1. Project Background and Motivation
2. Project Status and Accomplishments
3. Next Steps

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**Characterization of the Offshore Wilmington Graben  
For Large-Scale CO<sub>2</sub> Sequestration**



**Project Sponsors and Participants:**

- DOE NETL
- California Energy Commission
- City of Los Angeles, Department of Public Works
- Southern California Gas Company (transport infrastructure)
- Cal State Long Beach, Dr. Dan Francis (seismic acquisition)
- Legg Geophysics (seismic interpretation)
- USGS, Dr. Dan Ponti (cores and samples repository)
- University Of California, Irvine (microbiology)
- Terralog Technologies USA (geology, geomechanics, reservoir eng)

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### Characterization of the Offshore Wilmington Graben For Large-Scale CO<sub>2</sub> Sequestration

The Los Angeles Basin presents a unique combination of great need and great opportunity for large scale geologic storage of CO<sub>2</sub>.

In part due to its significant population, and in part due to its historical and geologic setting as one of the most prolific oil and gas producing basins in the United States, the region is home to more than a dozen major power plants and oil refineries, which produce more than 5 million metric tons of fossil fuel related CO<sub>2</sub> emissions each year.




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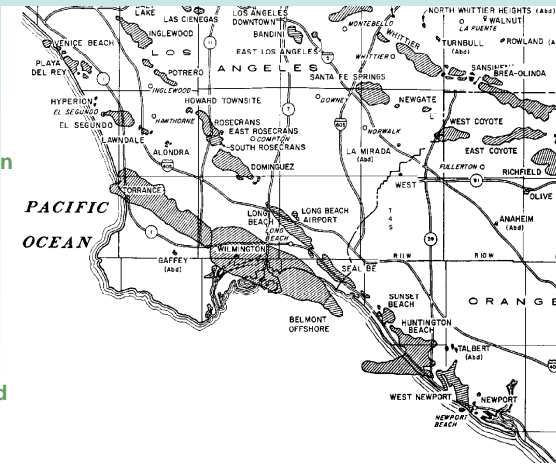
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### Characterization of the Offshore Wilmington Graben For Large-Scale CO<sub>2</sub> Sequestration


Pliocene and Miocene sediments in the Los Angeles Basin (massive interbedded sand and shale sequences) are known to provide excellent and secure traps for oil and gas.


The area contains several billion-barrel oil and gas fields, including the giant Wilmington Field in Long Beach (more than two billion barrels produced to date).

These formations have been used by Southern California Gas Company for very large-scale underground storage of natural gas at half a dozen locations throughout the Los Angeles basin for more than fifty years, demonstrating both the storage potential and security of these formations for CO<sub>2</sub> sequestration if properly characterized and selected.



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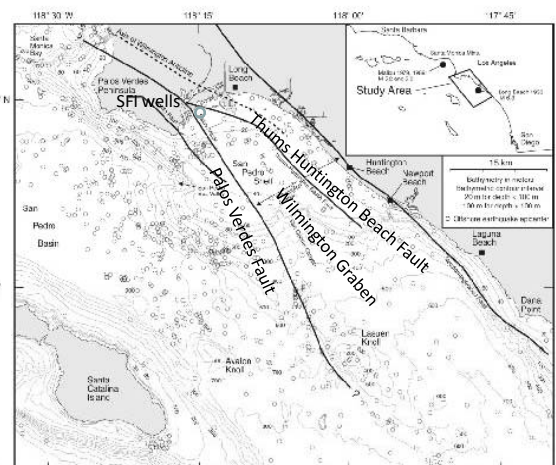
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Given the population density (and complex land ownership), it is impractical to site a large-scale CO<sub>2</sub> storage project onshore beneath the City.


More than 3000 feet thickness of Pliocene and Miocene formations are present in the large Wilmington Graben directly offshore the Los Angeles and Long Beach Harbor area, at appropriate depth for CO<sub>2</sub> sequestration (about 3000 to 7000 ft).

This zone is easily accessible yet geologically isolated from the nearby Wilmington Oilfield and onshore area, reducing communication risk and public risk.



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### Characterization of the Offshore Wilmington Graben For Large-Scale CO<sub>2</sub> Sequestration

Comprehensive research program to better characterize Pliocene and Miocene sediments in the Wilmington Graben and surrounding areas for high volume CO<sub>2</sub> storage. The effort includes:

- 1) Detailed log evaluation of existing exploration wells in the area;
- 2) Improved evaluation and interpretation of existing 2D and 3D seismic data;
- 3) Acquisition and interpretation of several additional 2D seismic lines;
- 4) Drilling and coring two new evaluation wells into the Graben (Pliocene and Miocene) and one on the landward side of the THUMS-HB fault
- 5) Development of 3D geologic models, geomechanical models, and CO<sub>2</sub> injection and migration models for the region.
- 6) Analysis of industrial sources (top 20 in the LA Basin)
- 7) Engineering study of existing and new pipeline systems to transport CO<sub>2</sub> from significant local sources to sequestration sites (transport infrastructure study)
- 8) Risk analysis (including well integrity, induced and natural seismicity)

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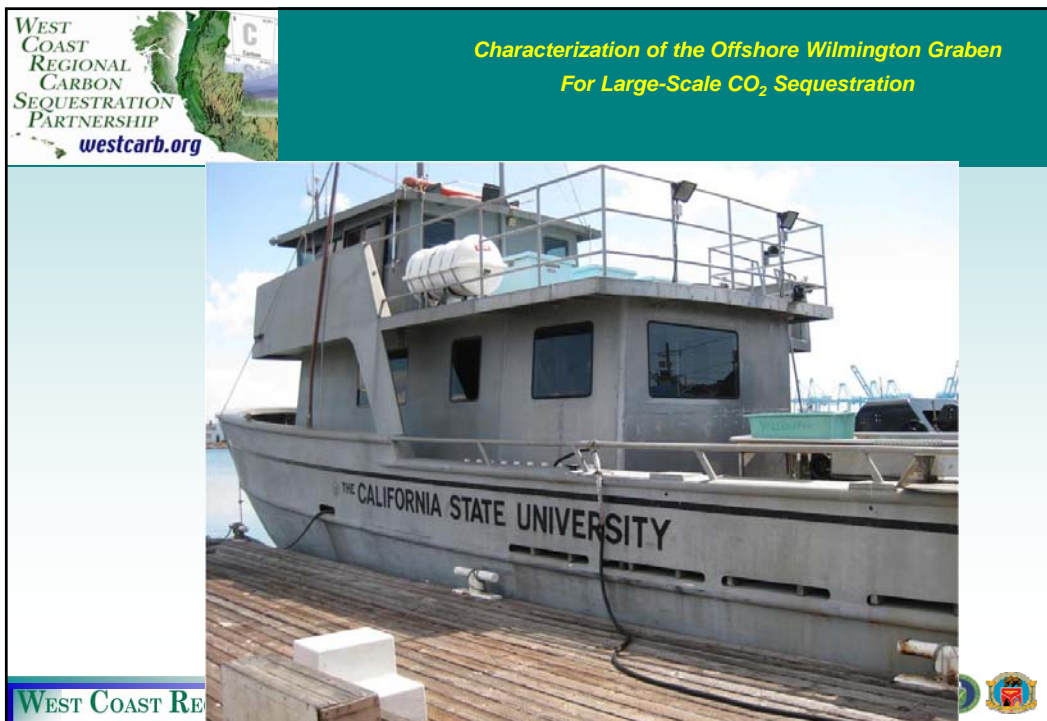
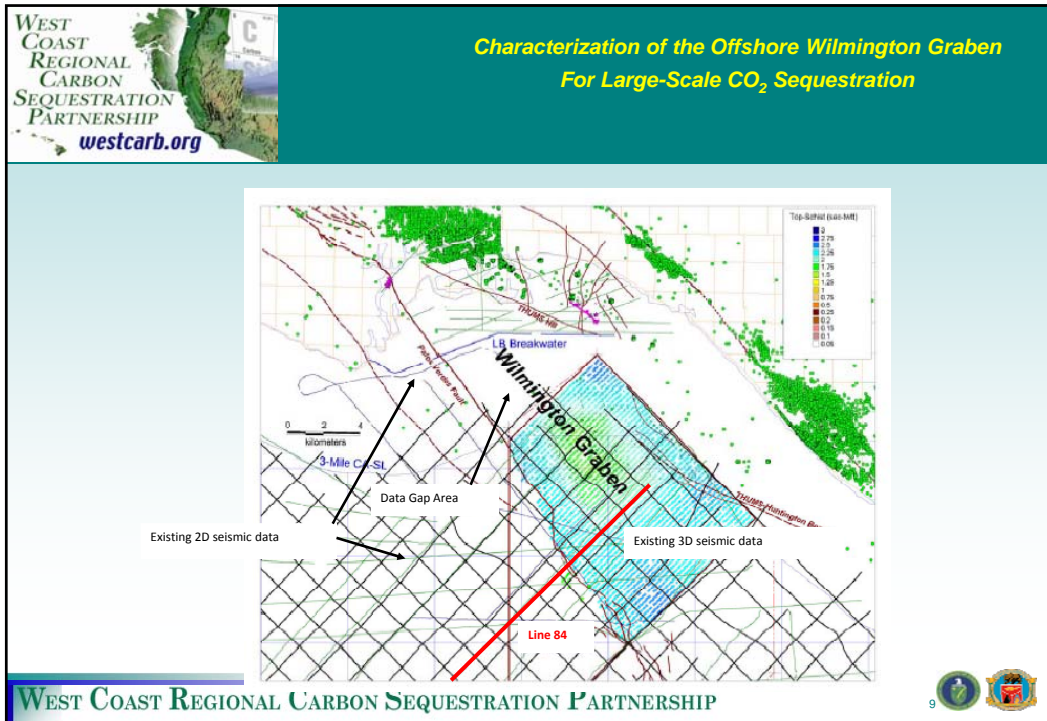
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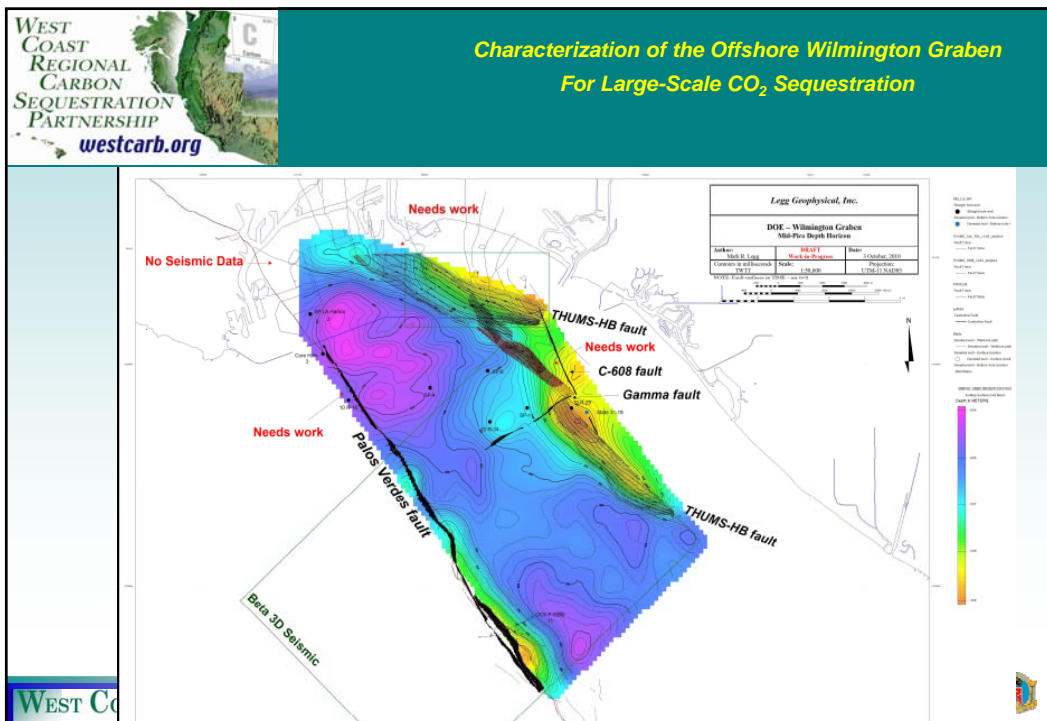
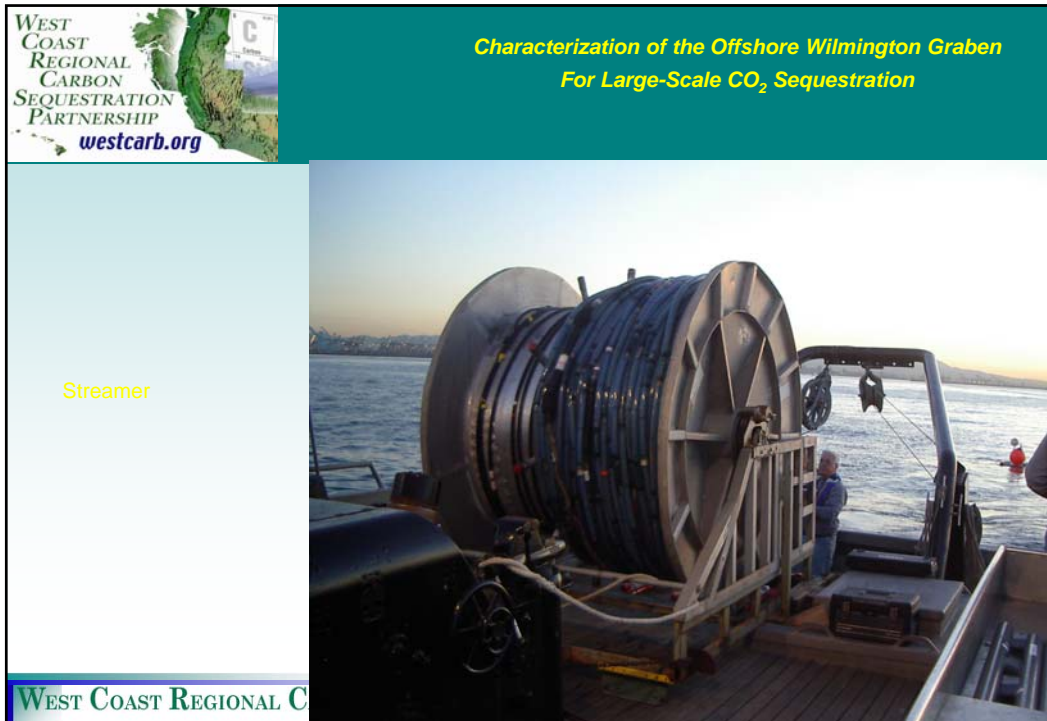
Exploration wells in Wilmington Graben

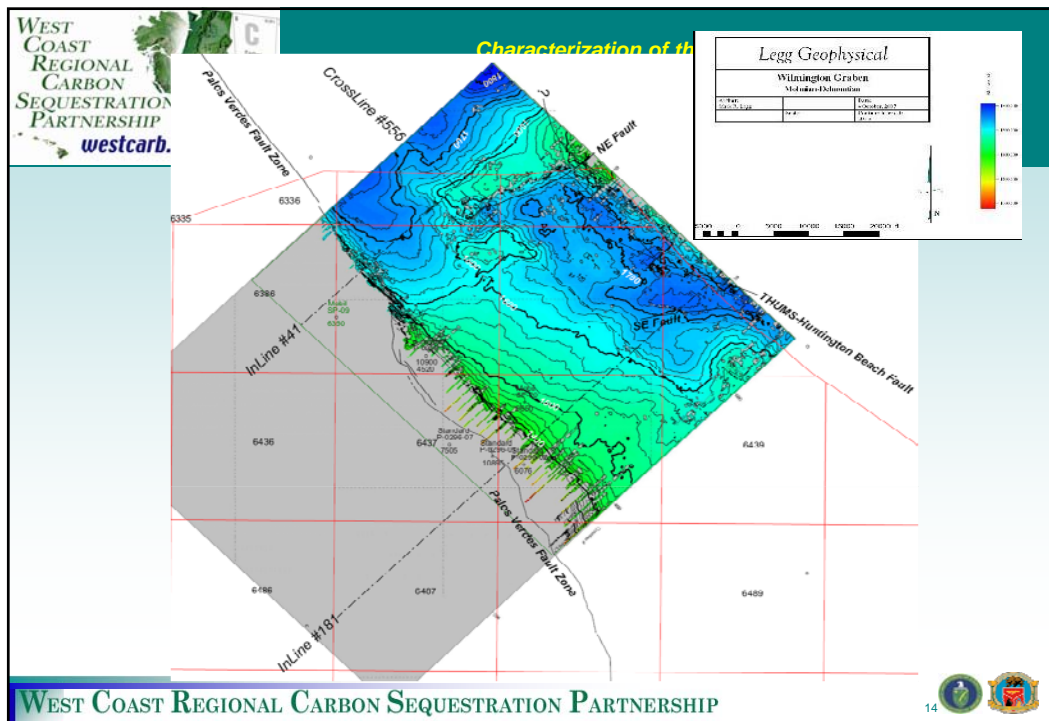
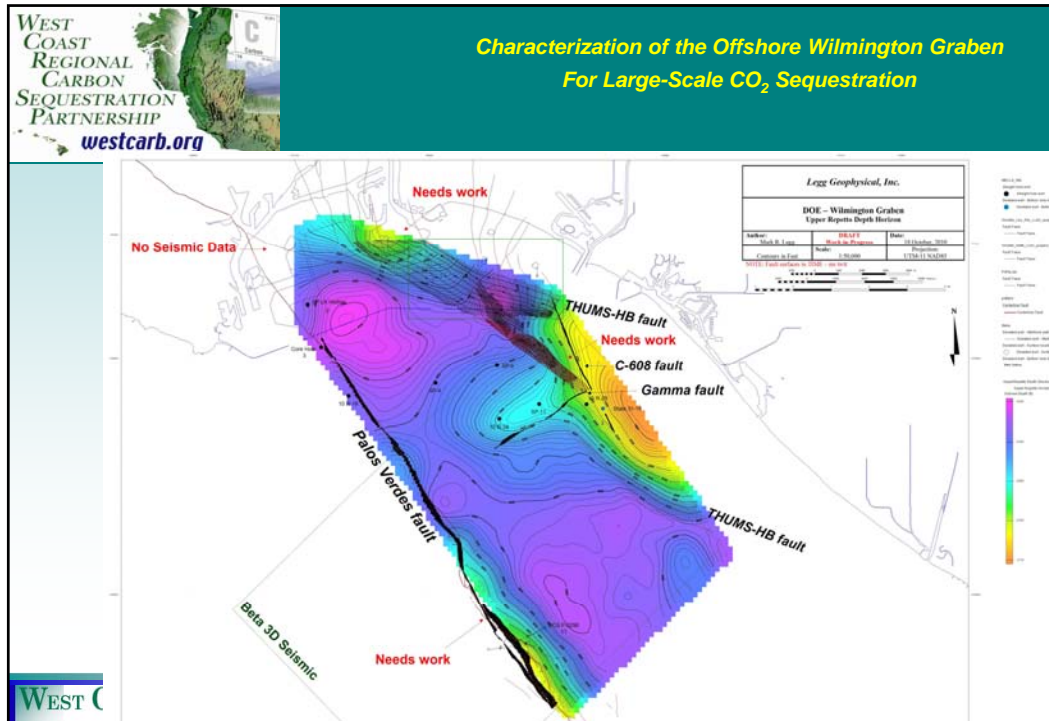


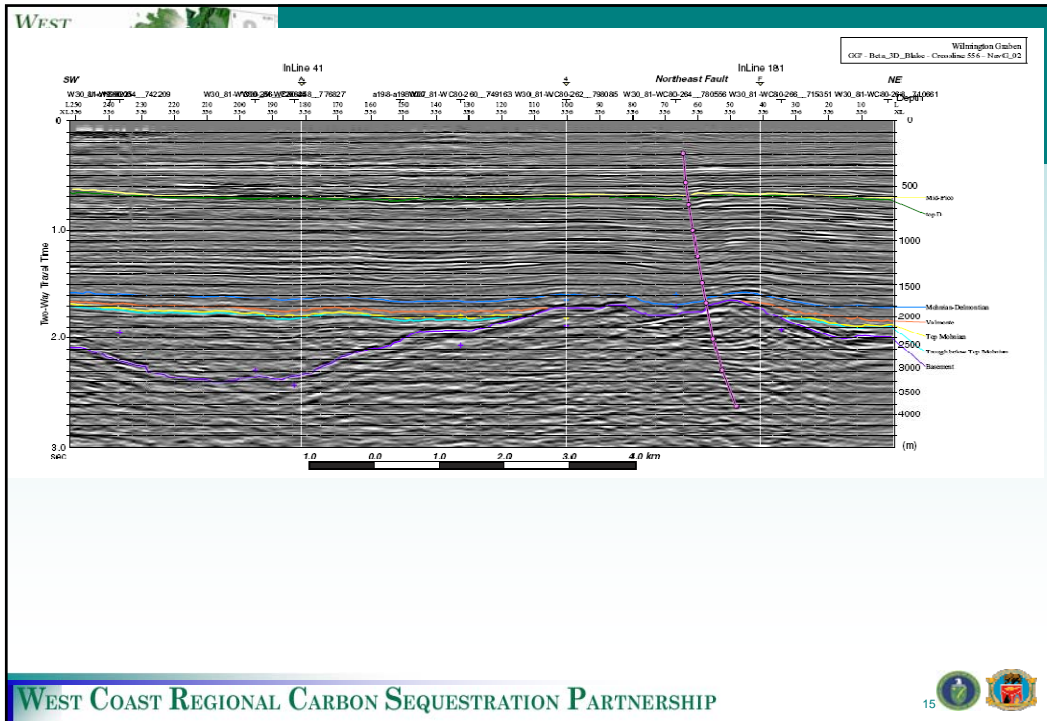
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Kenai Drilling Rig #38

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Conventional Core  
fresh out of hole



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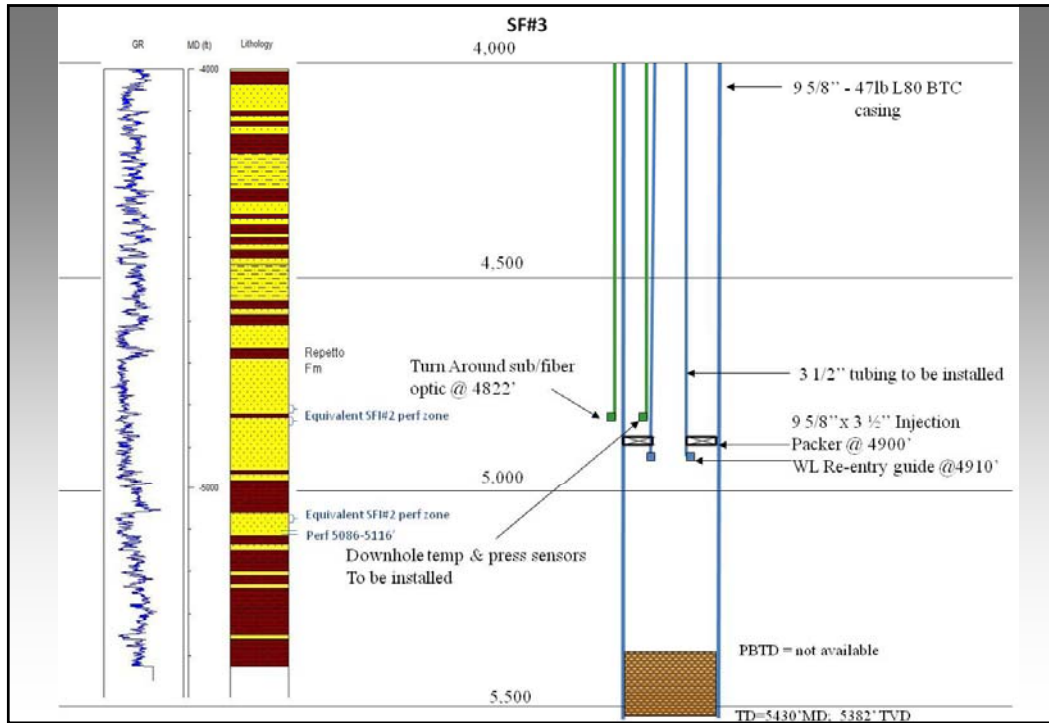
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	4420ft sand		4575ft sand		4605ft mudstone		4731ft sand
	4452ft sand		4585ft mudstone		4640ft sand		4805ft sand
	4505ft silt		4593ft mudstone		4673ft mudstone		4835ft sand
	4543ft mudstone		4597ft sand		4695ft sand		4867ft sand

SFI#3 Sidewall Core Samples

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**Reservoir Properties from SWC and Conventional Core**

Zones	Porosity (%)	Permeability (md)
Shale between 4465-4570ft	28 to 29	2 to 4
Sand at 4640ft	32	371
Shale above 4900ft sand	27	<1
4900ft sand @ 4690-4975ft	24 to 30	51 to 187
Shale above Injection Zone	28 to 29	<1 to 2
Injection Zone (5055-5115ft)	26 to 31	50 to 353
Sand at 5351ft	29	135
Conventional Core shale (5431-5439.5ft)	23 to 24	<1

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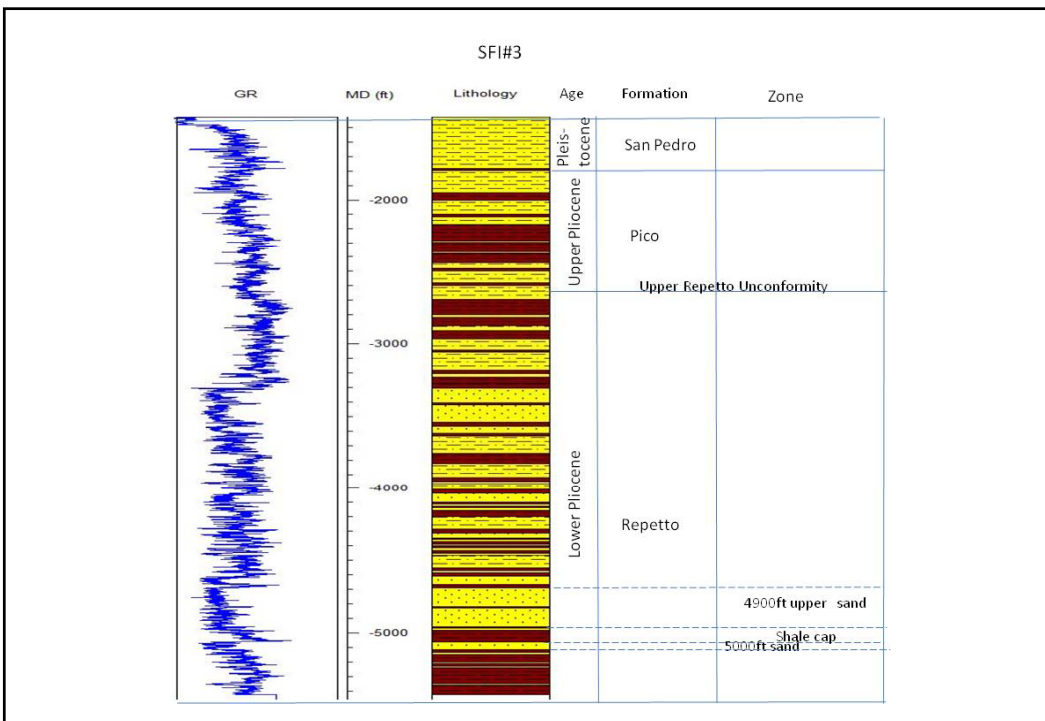
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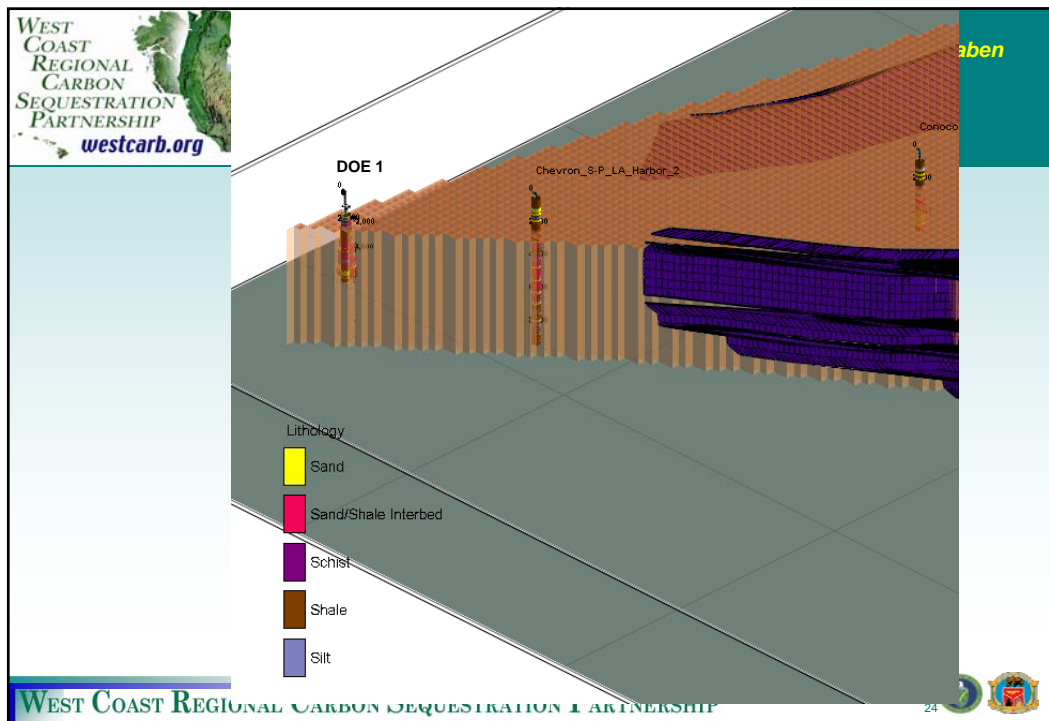
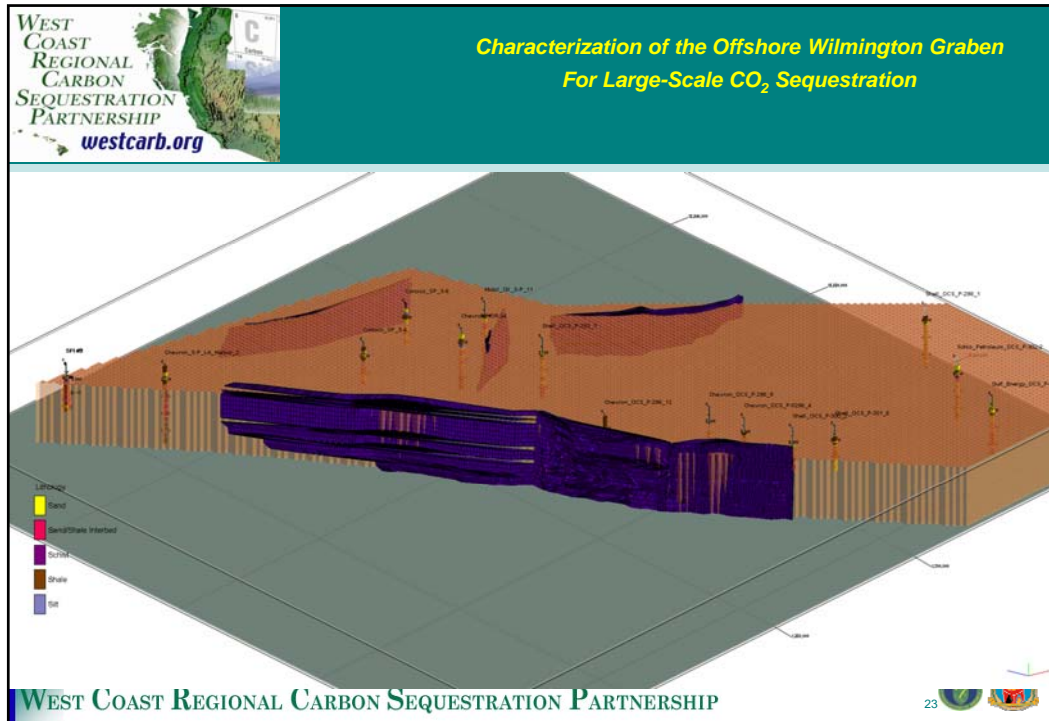
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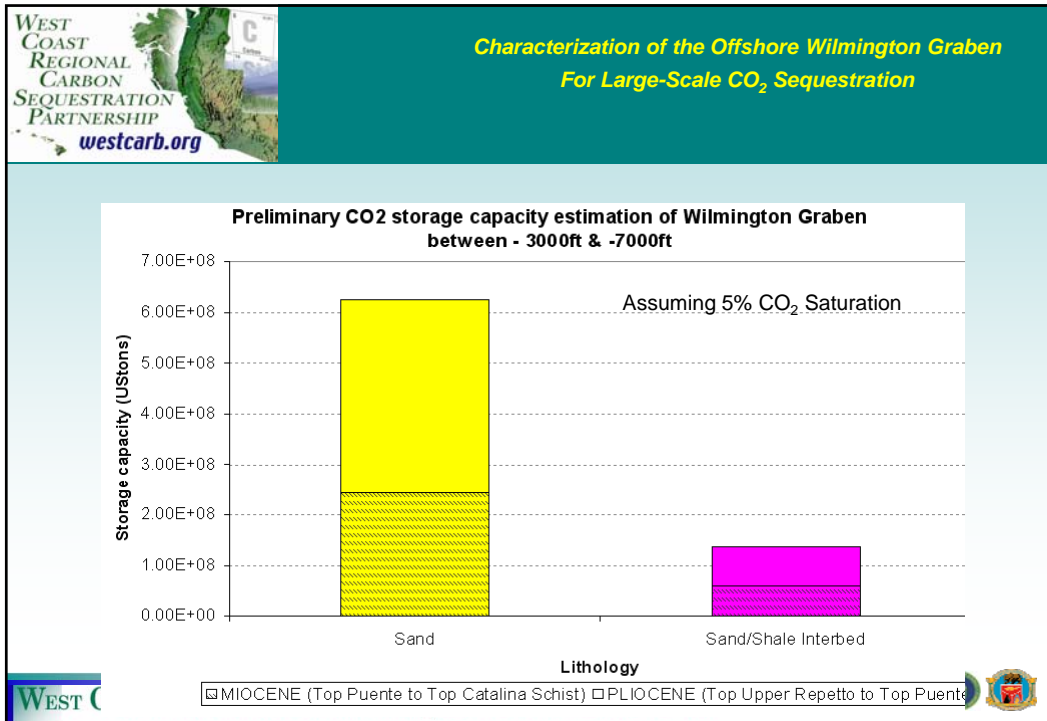
- Recovered 29 SWC and 9.5ft conventional core
- Correlated well with SFI#1 and SFI#2 wells
- Well TD in Pliocene based on micropaleontology correlation from SFI#2 well
- Sand porosities – 24-31%
- Sand permeabilities – 50-353md
- Shale porosities – 23-29%
- Shale permeabilities – <1-2md
- Pliocene sand thickness – 3000-3500ft

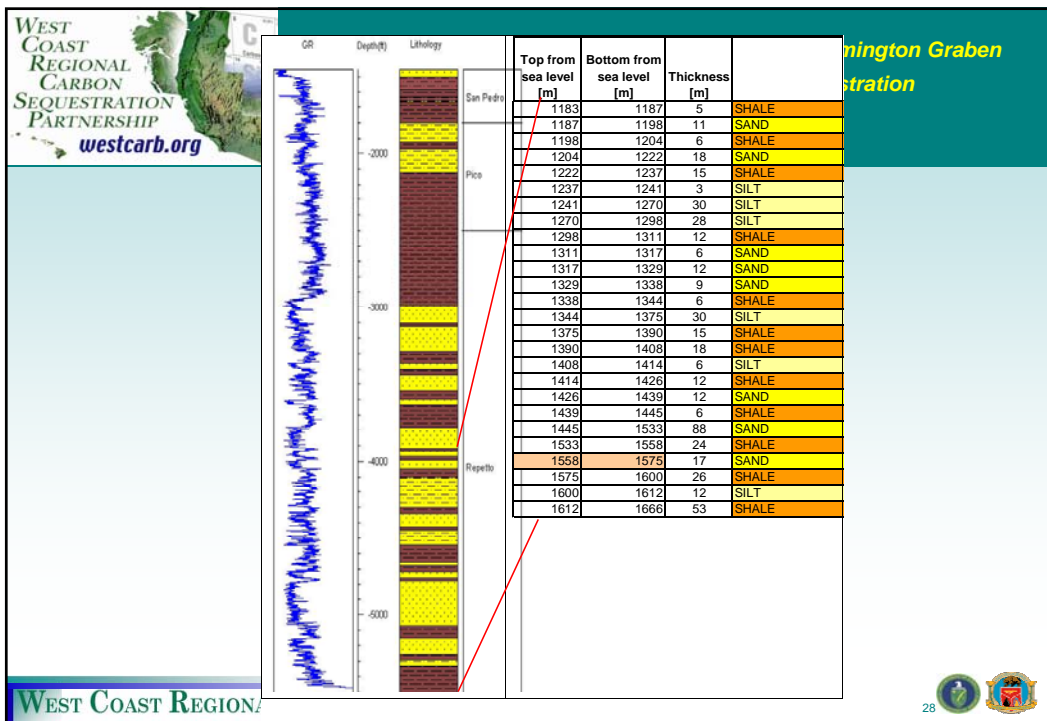
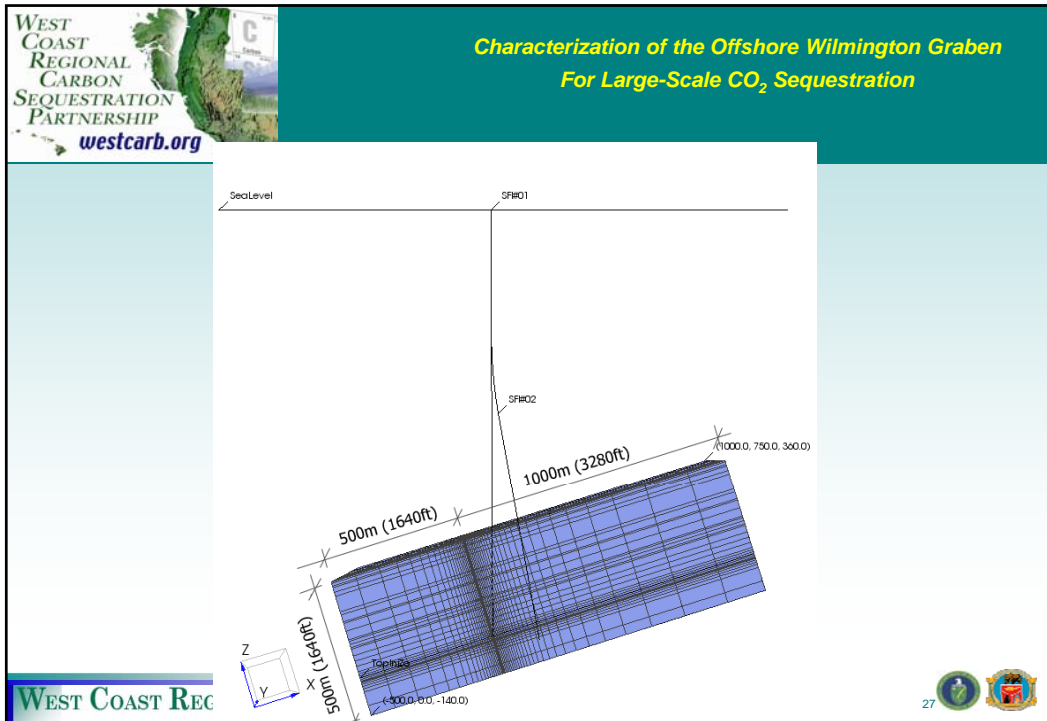
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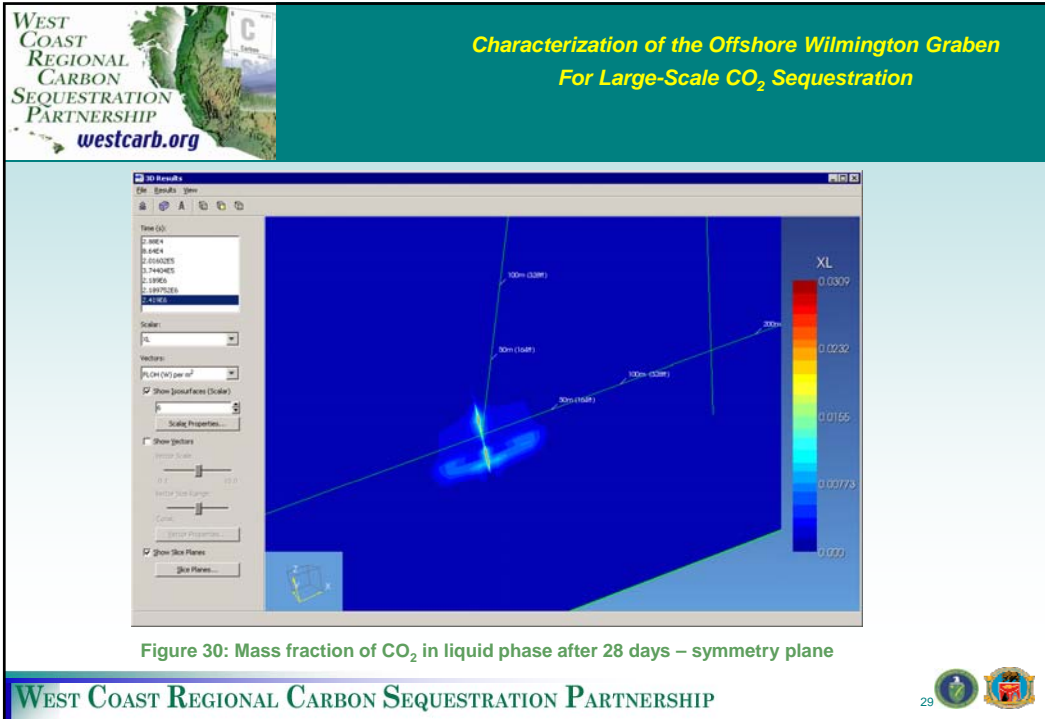




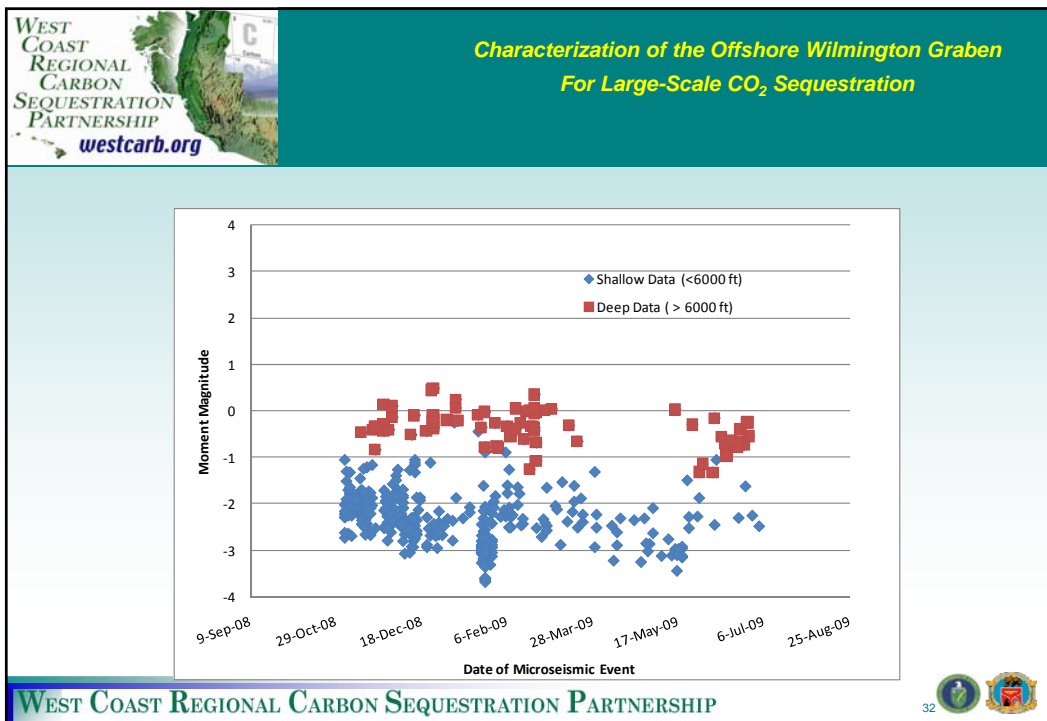
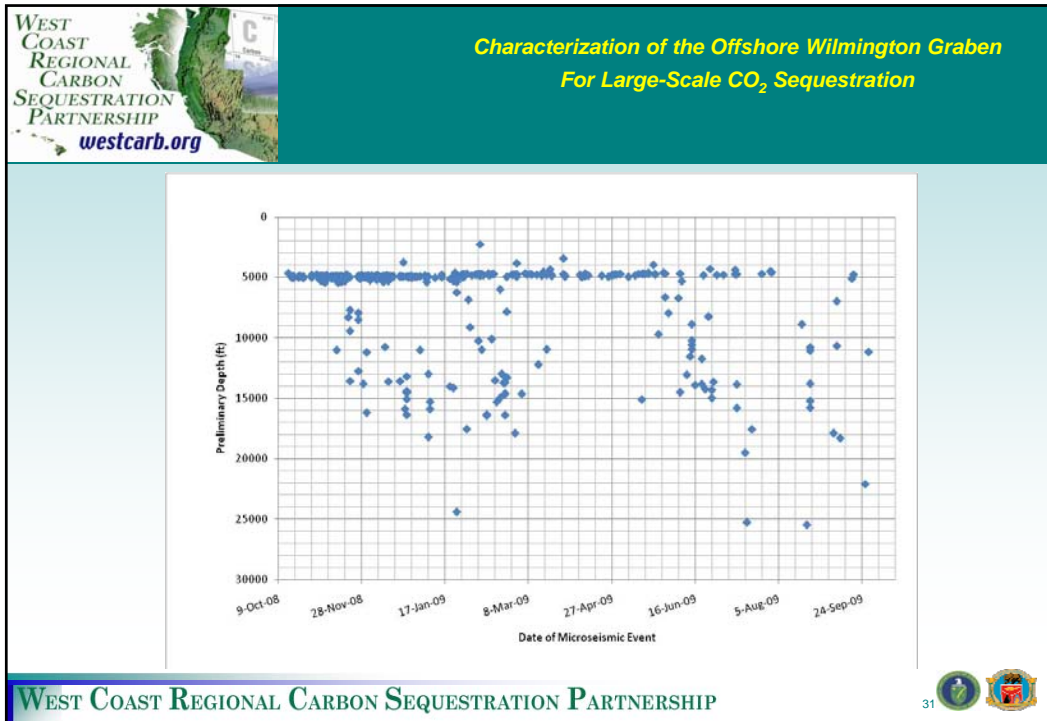




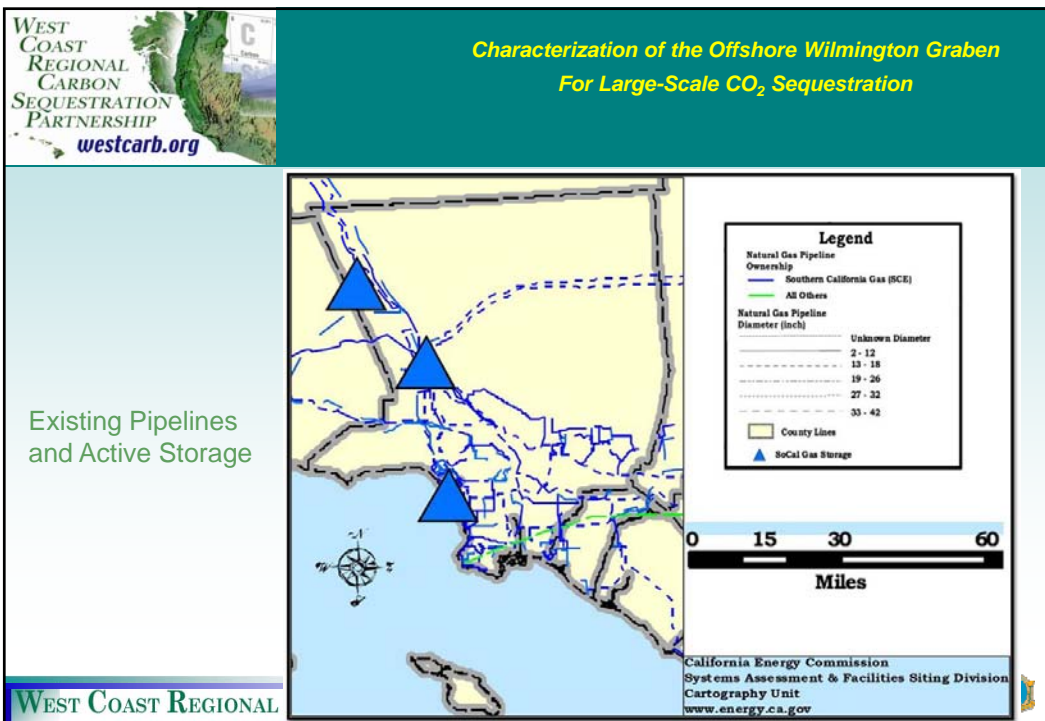
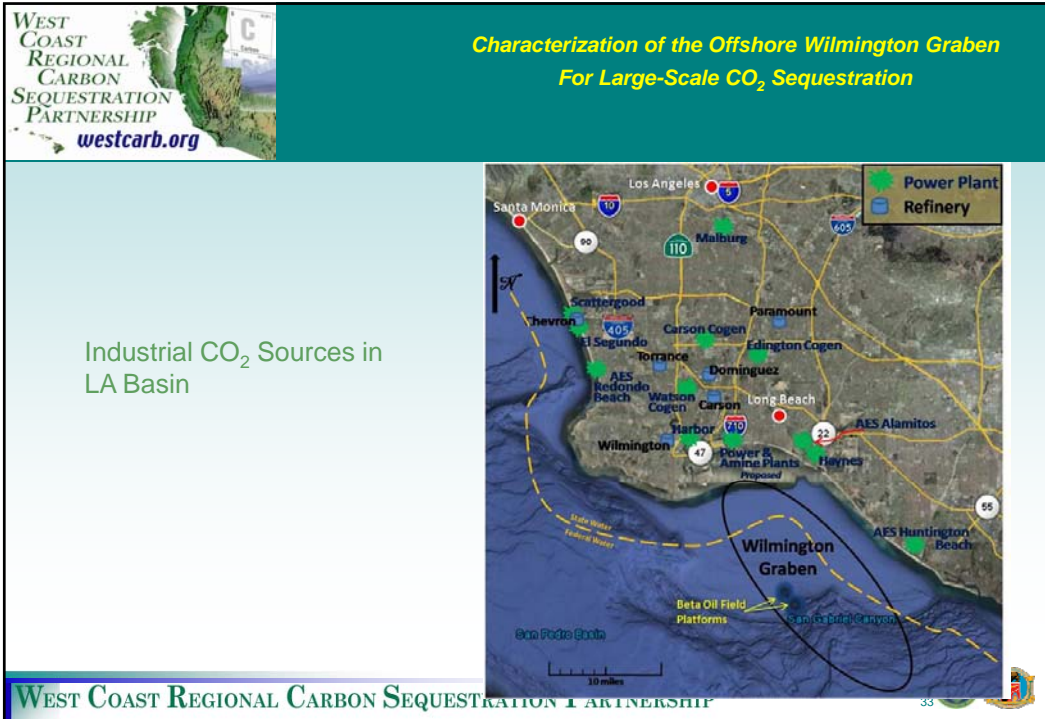




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- Characterization of the Offshore Wilmington Graben  
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- Risk Assessment and Documentation Includes:
- Seal continuity and uncertainty;
  - Existing well completion integrity (primarily cement);
  - Seeps along faults;
  - Natural seismicity (historical impact on O&G and gas storage operations in LA Basin);
  - Induced seismicity (characterization of target sands, analog injection monitoring);
  - Spill points, long-term permeation through caprock;
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**Characterization of the Offshore Wilmington Graben  
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- Acquired 175km of new seismic lines
- Drilled 1<sup>st</sup> characterization well into Pliocene
- Rock properties collected for Pliocene formation
- Preliminary structure maps constructed for 4 horizons
- Reviewed all exploratory wells and loaded into 3D Geologic Model (static and dynamic simulation)
- Initiated CO<sub>2</sub> migration modeling (TOUGH2) and geomechanical modeling (FLAC3D)
- Preliminary storage estimates >100MT




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Next Steps:

- Improve 3D geologic model, Oct-Dec 2010
- Additional seismic acquisition in 2011 to better define fault closure
- Additional characterization wells in 2011 and 2012
- Develop geomechanical model for northern and central areas
- Expand reservoir flow modeling (local and regional scale)
- Complete engineering studies of LA Basin sources and transportation systems
- Risk characterization and documentation

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