Mid-Atlantic U.S. Offshore Carbon Storage Resource Assessment

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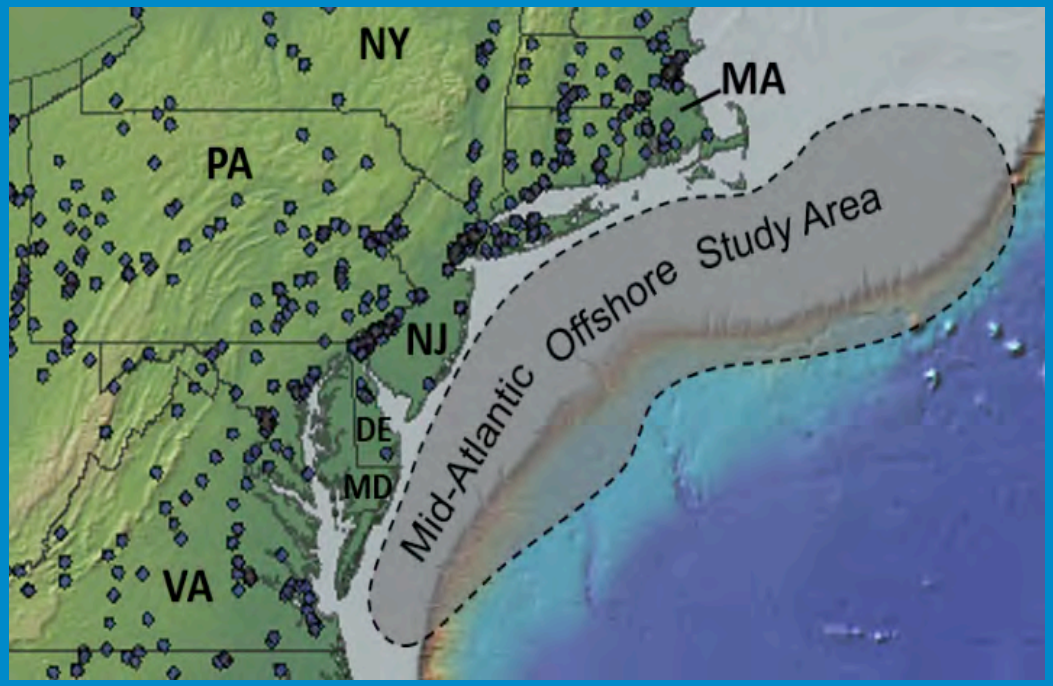

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Acknowledgement

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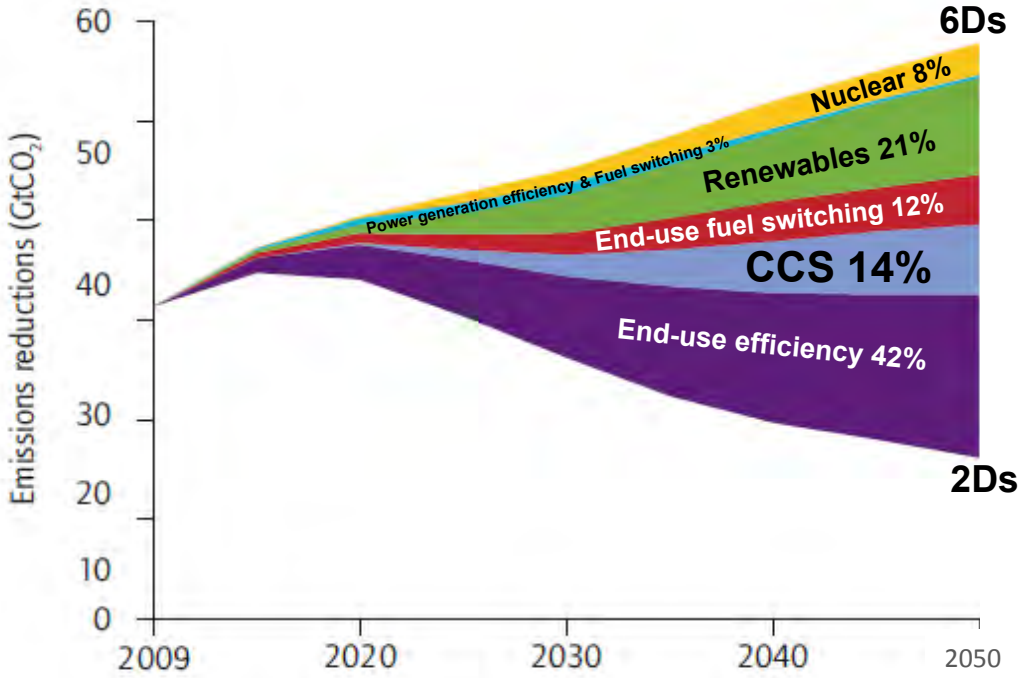
Disclaimer

A brief project overview will be provided

- Background
  - Why is the project important?
  - What is special about the study area?
  - What is a carbon storage resource assessment?
- Project Scope
  - What are the project's objectives?
  - How will they be achieved?
  - What are the schedule and deliverables?
- Discussion
  - What progress has been made?
  - What does the future hold?

Why is the project important?

Very few scenarios achieve climate goals without CCS



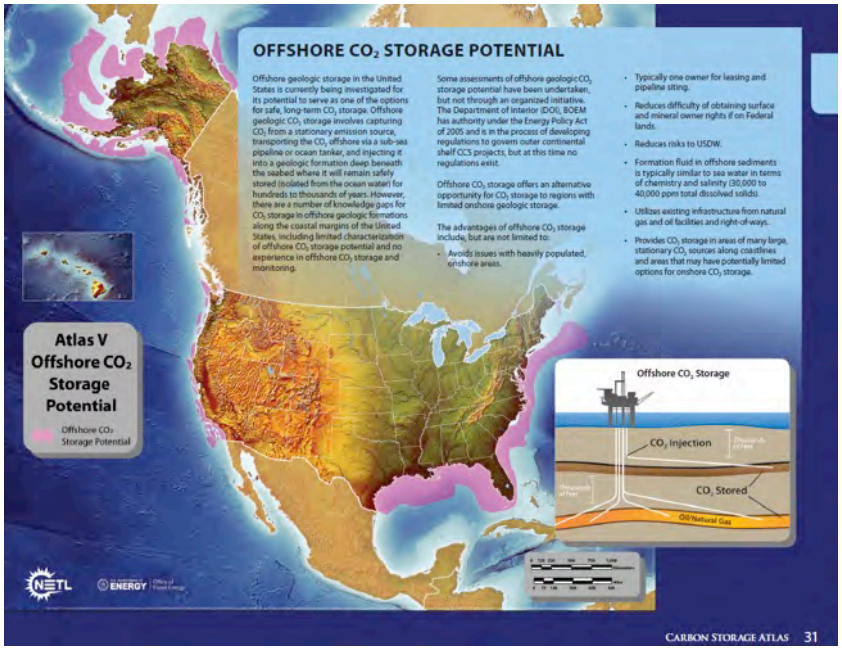
Source: IEA Energy Technology Perspectives 2014

- CCS technology tested & ready for large-scale deployment
- In need of economic &/or policy drivers

Why is the project important?

Good policy is informed by science

- The key outcome of this project will be to develop an informative picture of storage potential
  - Prospective storage resource info and identification of offshore reservoirs with the greatest potential for effective, technically feasible storage
  - Identification of the geological, logistical, and public perception issues for geologic storage in the mid-Atlantic coastal region
  - Guidelines/roadmap to promote future carbon capture and storage activities



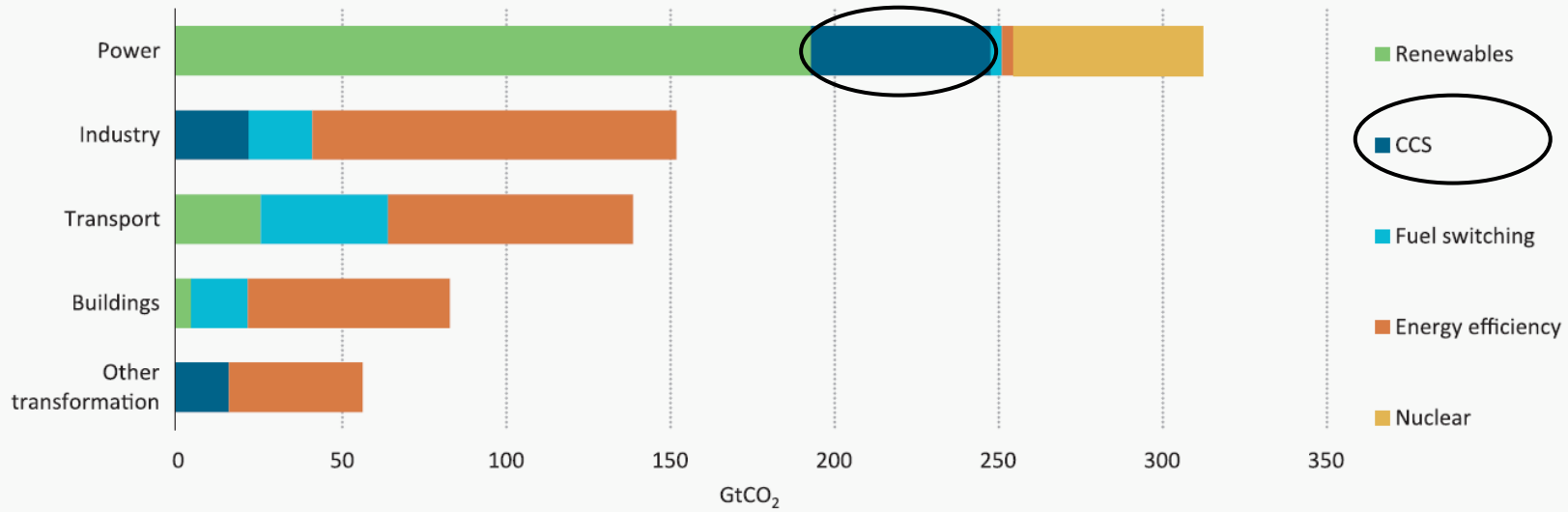
Source: Atlas V, NETL, 2015

http://www.netl.doe.gov/research/coal/carbon-storage/natcarb-atlas/co2-storage-form

Why is the project important?

CCS is vital for meeting emission reductions in the power, industry and other sectors

Figure I.1 Cumulative CO_2 reductions by sector and technology in the 2DS to 2050

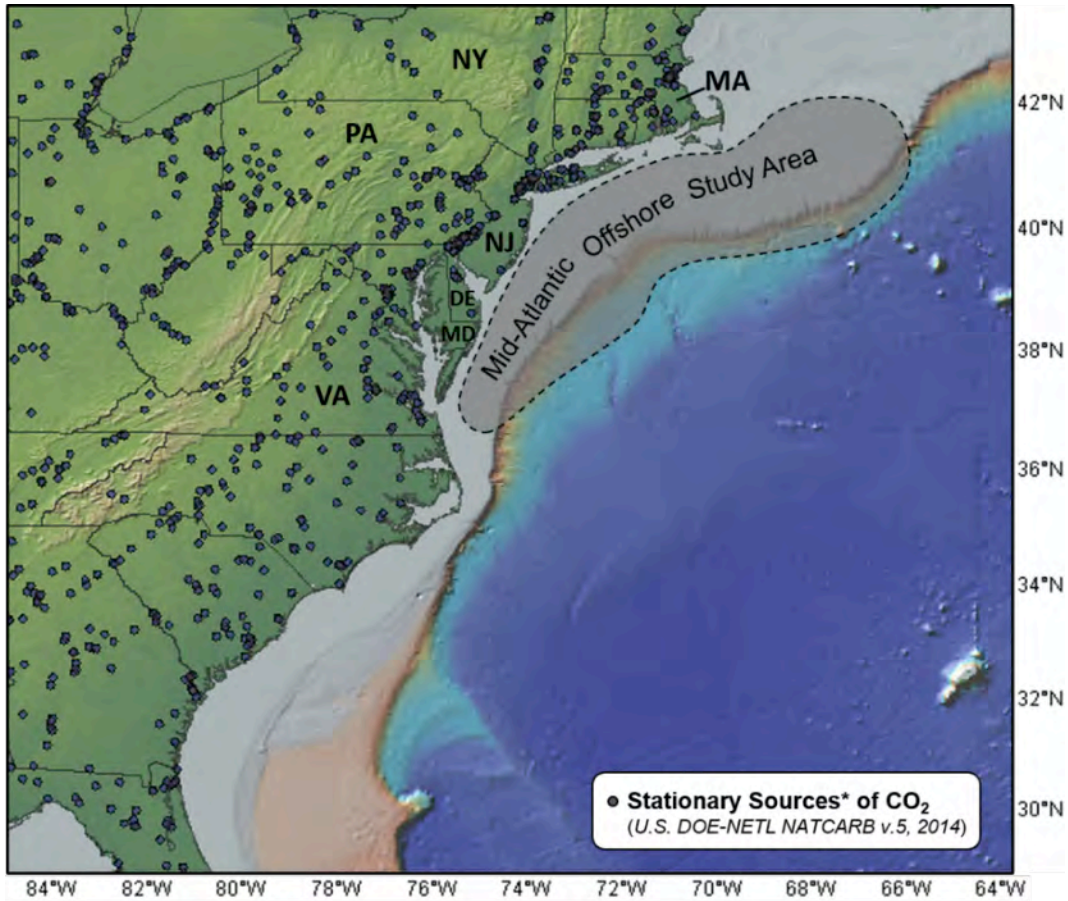


Key point *A portfolio of low-carbon technologies is needed to reach the 2DS; some solutions will be broadly applicable, while others will need to target specific sectors.*

Source: IEA Energy Technology Perspectives 2015

What is special about the study area?

Characterized by numerous point sources which could be matched to storage

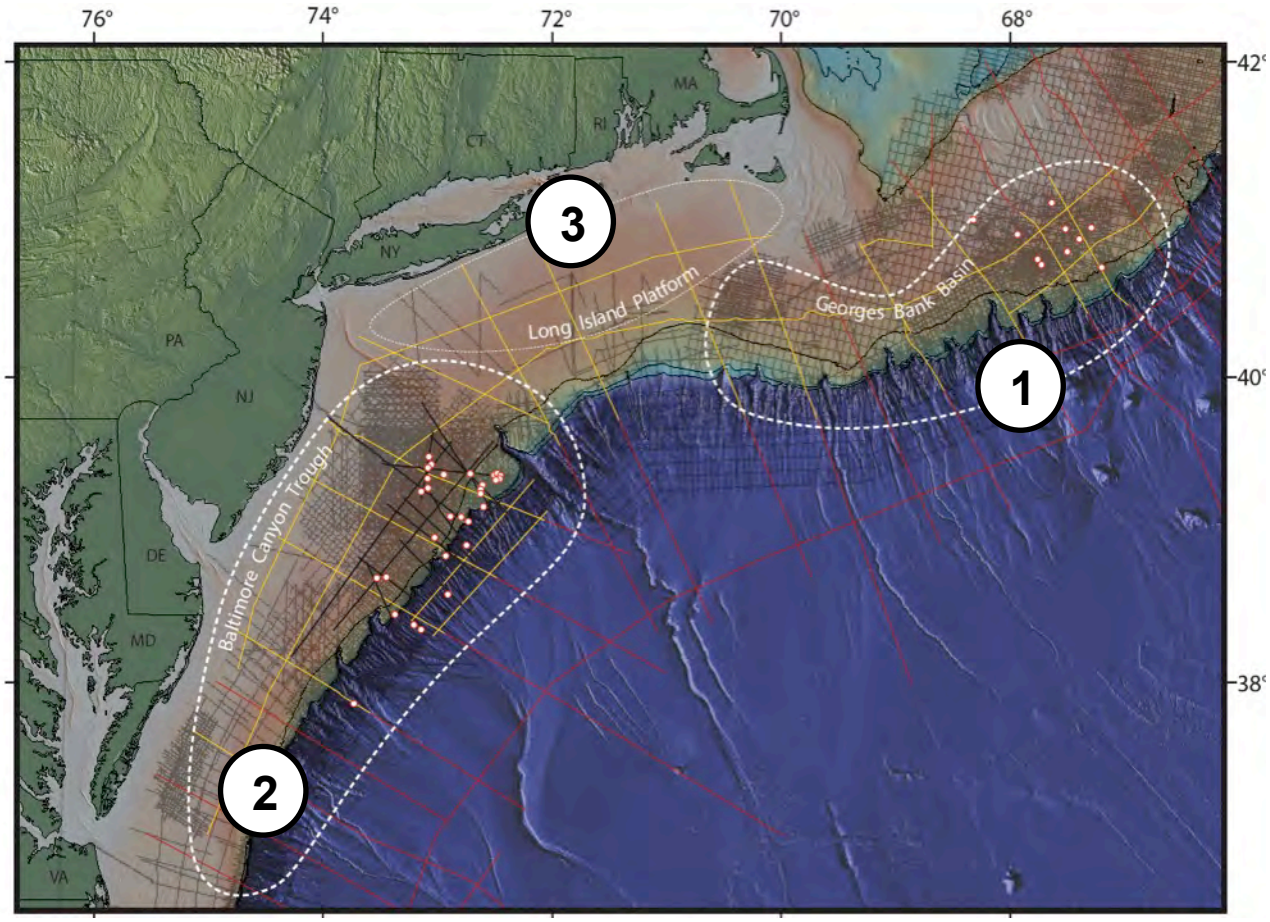


- Addresses heavily populated Mid-Atlantic States: Virginia, Maryland, Delaware, New Jersey, Pennsylvania, New York
- Potential storage within the mid- and north-Atlantic Planning Areas

What is special about the study area?

Includes three major sub regions

1. Georges Bank Basin
2. Baltimore Canyon Trough
3. Long Island Platform



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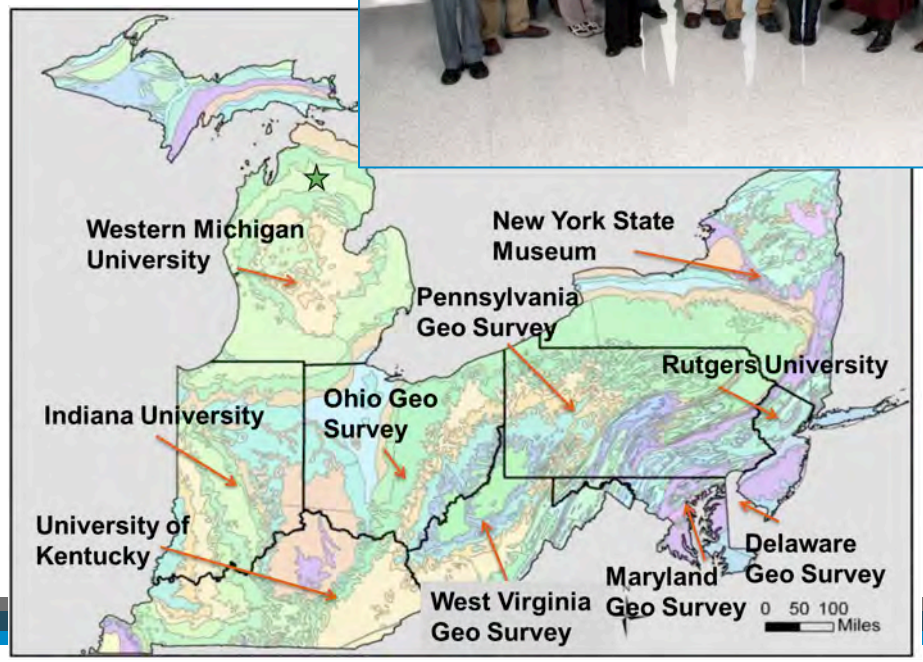
What is special about the study area?

Synergistic with MRCSP projects

Collaborative geologic storage potential mapping with state geological surveys and universities

MRCSP's geology team



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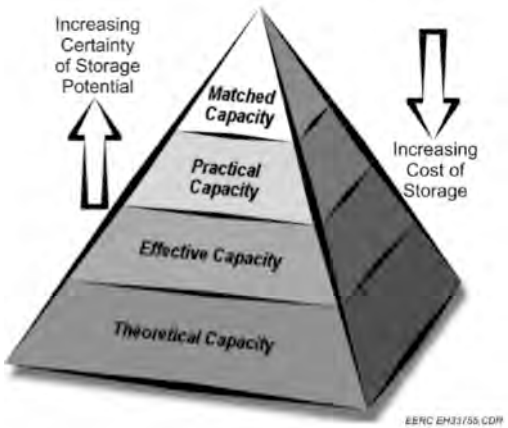
What is a carbon storage resource assessment?

Defining Terminology & Classification Systems

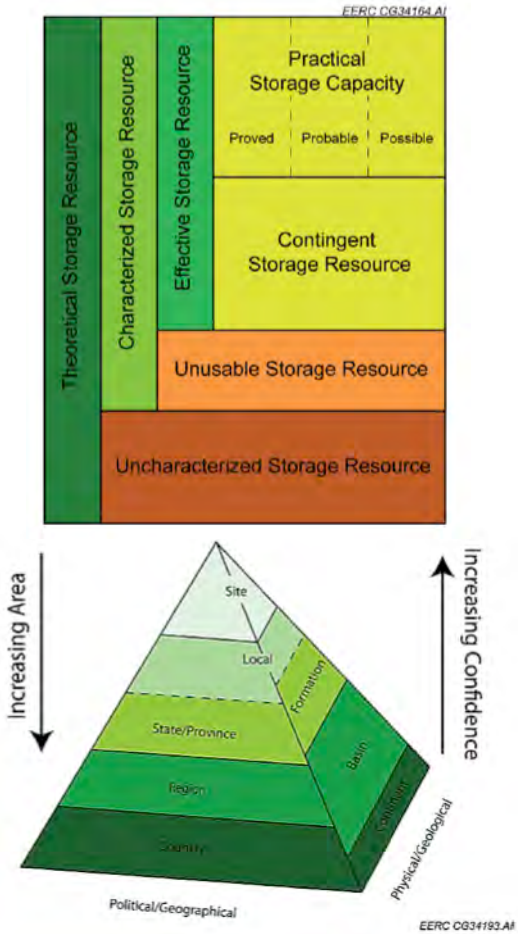


CSLF, 2008

Petroleum Industry		CO_2 Geological Storage
Reserves	Implementation	**Capacity**
On Production		Active Injection
Approved for Development		Approved for Development
Justified for Development		Justified for Development
Contingent Resources	Site Characterization	**Contingent Storage Resources**
Development Pending		Development Pending
Development Unclarified or On Hold		Development Unclarified or On Hold
Development Not Viable		Development Not Viable
Prospective Resources	Exploration	**Prospective Storage Resources**
Prospect		Qualified Site(s)
Lead		Selected Areas
Play		Potential Sub-Regions

Exploration	Prospective Storage Resources	
	Project Sub-class	Evaluation Process
	Qualified Site(s)	Initial Characterization
	Selected Areas	Site Selection
	Potential Sub-Regions	Site Screening

US-DOE-NETL, 2010



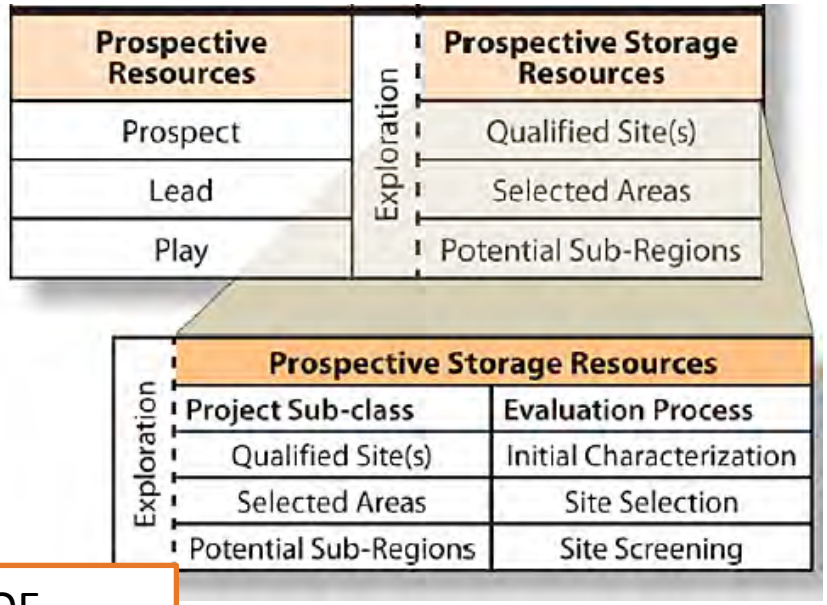
IEAGHG, 2008

What is a carbon storage resource assessment?

Resource vs Capacity

CO_2 Storage Resource: The pore volume of a potential storage formation that is accessible to injected CO_2 via drilled and complete wellbores. Can have subset of qualifiers (e.g. Theoretical, Effective, Prospective, Contingent).
Exploration phase

CO_2 Storage Capacity: Quantity of CO_2 that can be commercially stored in a formation in a given timeframe under specific economic & regulatory constraints such as: land use, field/ operational conditions, costs, proximity to CO_2 source.
Implementation phase



US-DOE-NETL, 2010

Since 2009 all major methodologies (DOE, CSLF, USGS, IEAGHG) have adopted the "Storage Resource" vs "Storage Capacity" distinction in their terminology .

What is a carbon storage resource assessment?

US-DOE-NETL Methodology

$$G_{CO2} = A_t\, h_g\, \phi_{tot}\, \rho_{CO2} E_{saline}$$

total pore volume — fluid properties — efficiency

- Open Boundaries
- Regional Scale
- Physical Trapping

Parameter	Units*	Description
G_{CO2}	M	Mass estimate of saline formation CO_2 storage resource.
A_t	L^2	Geographical area that defines the basin or region being assessed for CO_2 storage.
h_g	L	Gross thickness of saline formations for which CO_2 storage is assessed within the basin or region defined by A.
ϕ_{tot}	L^3/L^3	Total porosity in volume defined by the net thickness.
ρ	M/L^3	Density of CO_2 evaluated at pressure and temperature that represents storage conditions anticipated for a specific geologic unit averaged over h_g and A_t.
E_{saline}	L^3/L^3	CO_2 storage efficiency factor that reflects a fraction of the total pore volume that is filled by CO_2.

What are the project objectives?

Project objectives are aligned with DOE goals

Carbon Storage Program Goal	Mid-Atlantic U.S. Project Objectives
Support industry's ability to predict CO_2 storage capacity	Define the geologic characteristics of candidate storage sites Use seismic data to better define continuity of reservoirs and seals Catalog hydrologic properties of mid-Atlantic offshore storage sites Determine appropriate efficiency parameters specific to offshore lithology
Develop Best Practice Manuals	Examine risk factors Engage stakeholders to guide future projects

How will the objectives be achieved?

Diverse, qualified project team

Sponsors

DOE

Project Lead

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Technical Advisory Committee

Daniel Schrag (Harvard)
Tip Meckel (BEG)
David Spears (Virginia)

Project Management (Task1)

Project Manager: Lydia Cumming
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Task 8

Reporting & Tech Transfer

Lydia Cumming (Battelle)

Task 2

Offshore Geological Characterization

Ken Miller (Rutgers)

Task 3

Seismic Evaluation

Greg Mountain (Rutgers)

Task 4

Hydrologic Properties Characterization

Peter McLaughlin (Delaware Geo. Survey)

Task 5

Carbon Resource Calculations

Isis Fukai (Battelle)

Task 6

Risk Factor Analysis

Joel Sminchak (Battelle)

Task 7

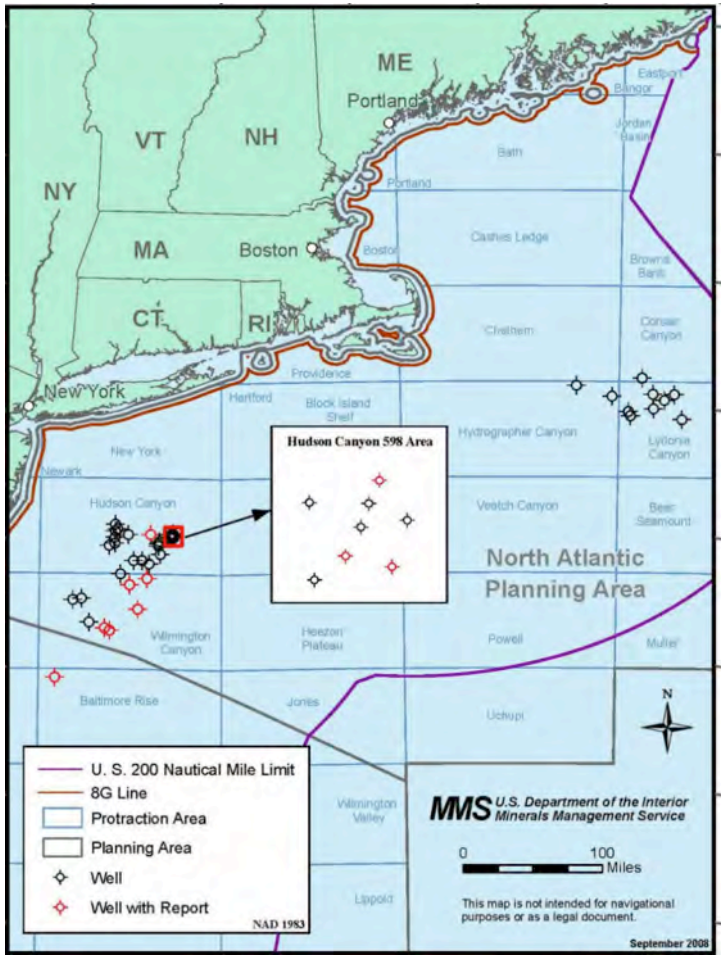
Stakeholder Education & Engagement

Kristin Carter (Pennsylvania Geo. Survey)

How will project objectives be achieved?

Define the geologic characteristics of candidate storage sites

- Compilation and review of all existing available data
- Construction of a digital database
- Interpretation of porosity and mineralogy using well logs and core
- Correlation and calibration of seismic data with well log data
- Construction of new storage and seal formation maps and cross-sections

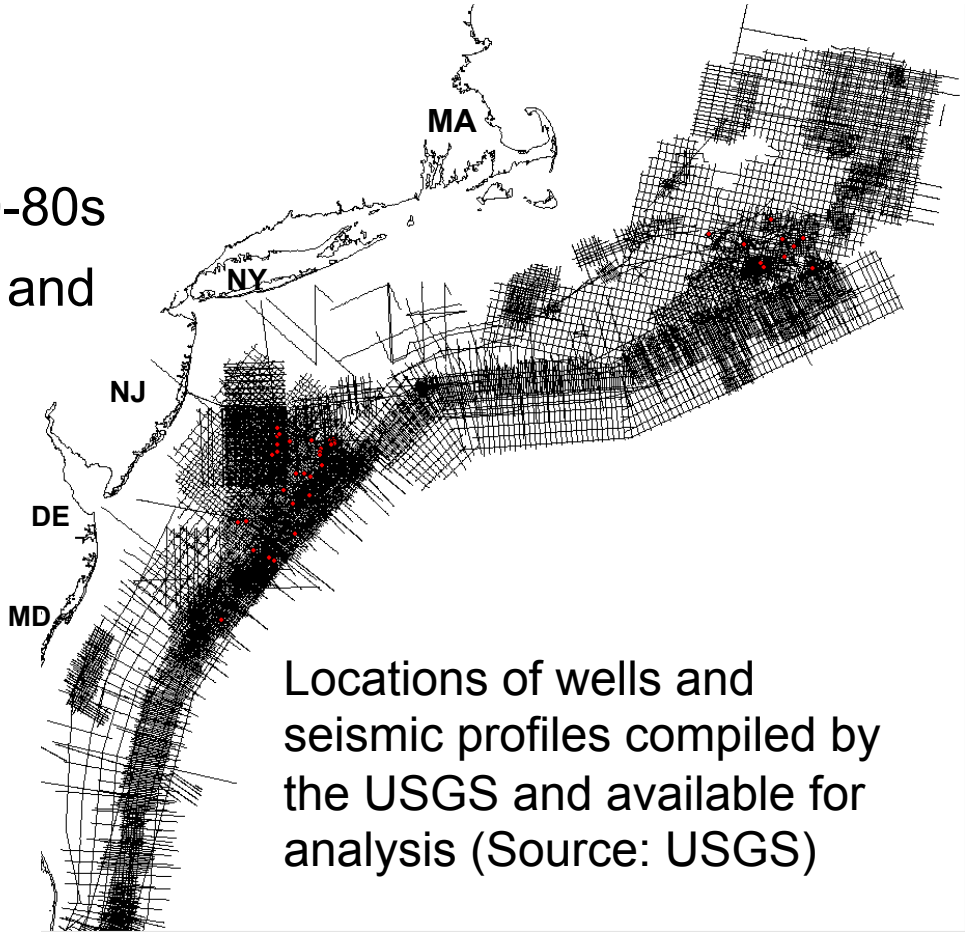


From Brian Slater, Stolorow, and Smith, 2011

How will project objectives be achieved?

Use seismic data to better define continuity of reservoirs and seals

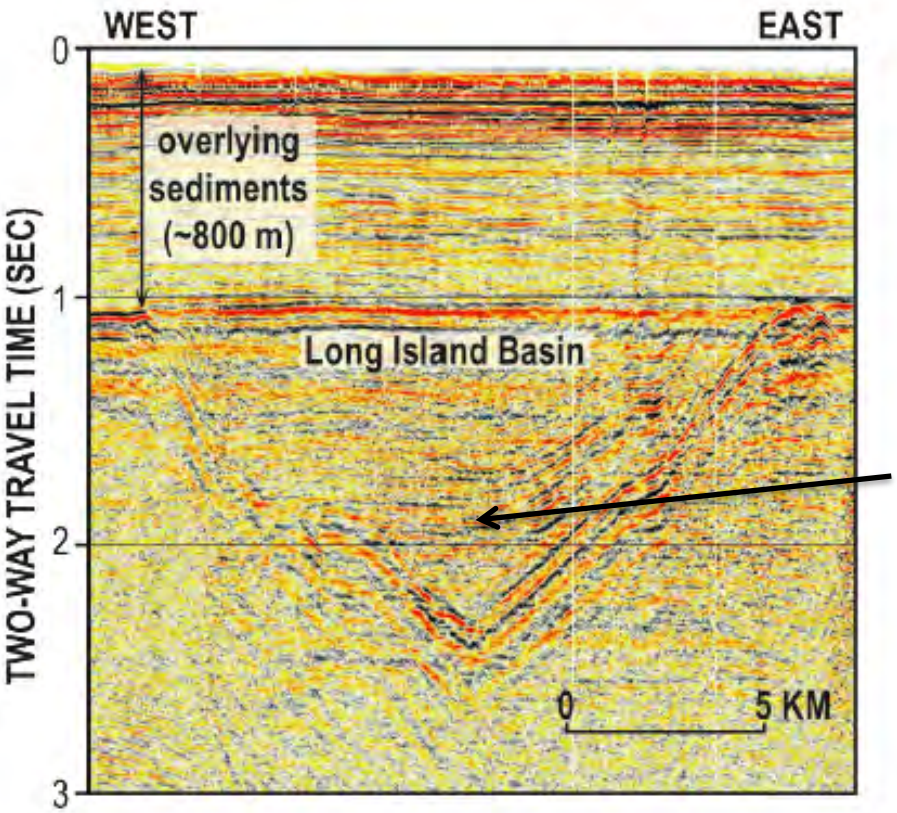
- BOEM newly released industry multichannel seismic data from 70-80s
- Augmented with lines from USGS and academia
- Dense data grid of 2-D seismic reflection lines on shelf and slope from Cape Hatteras to Georges Bank
- Variability in vintages, navigation quality and acquisition parameters



Locations of wells and seismic profiles compiled by the USGS and available for analysis (Source: USGS)

How will project objectives be achieved?

Use seismic data to better define continuity of reservoirs and seals



- Modern workflow processing will be applied to go beyond basic steps previously applied to enhance resolution

Poor resolution of basement structures, which may represent potential storage reservoirs

Example of unprocessed seismic data along the Long Island basin (after Hutchinson et al., 1986)

How will project objectives be achieved?

Catalog hydrologic properties

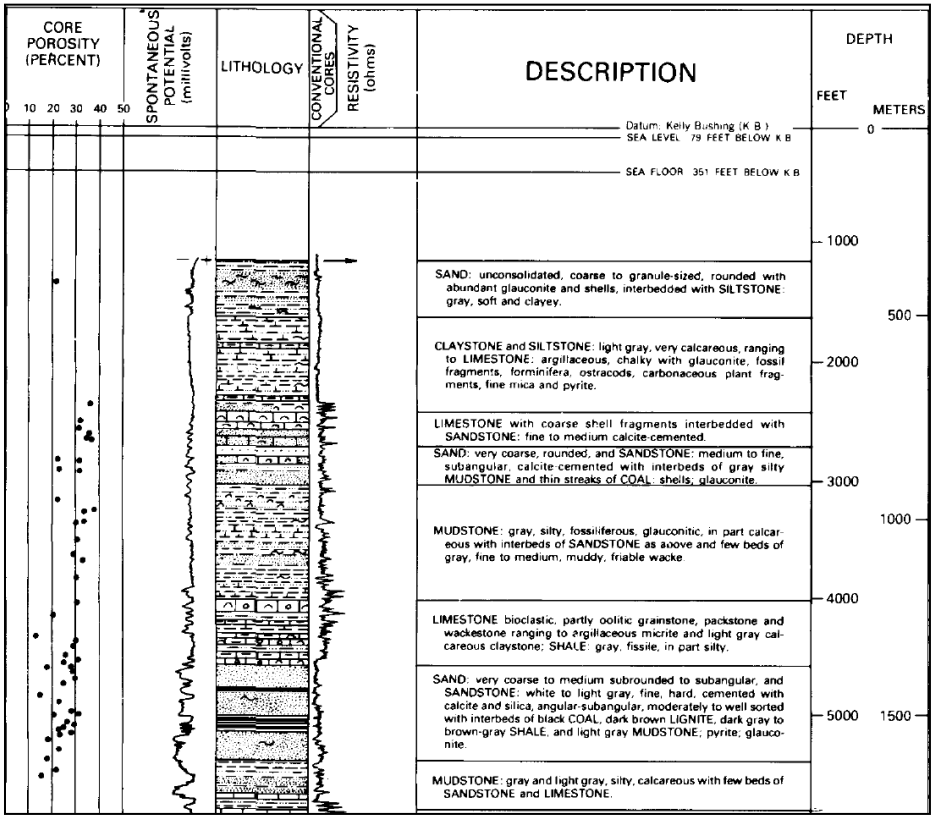
- Collection of data to help determine pore space available for CO_2 storage and the distribution, movement of fluids - including lithology, porosity, permeability
- Use existing data in reports from the era when the wells were drilled
- New data generated by selecting core material available in the DGS Outer Continental Shelf Sample Repository

Example of DGS core repository holdings, COST G2 well

How will project objectives be achieved?

Catalog hydrologic properties

- Physical and hydrologic properties of formations will be determined from existing well log data in the public domain
- Well log data will be compared to and calibrated with existing core data



From Amato, R. V., Simonis, E. K., 1980, US Geological Survey Open File Report 80-269

How will project objectives be achieved?

Determine appropriate efficiency parameters specific to offshore lithology

- Develop first approximations of offshore CO_2 storage efficiency
- Examine differences between onshore and offshore environments in terms of storage efficiency

Net Effective Pore Volume

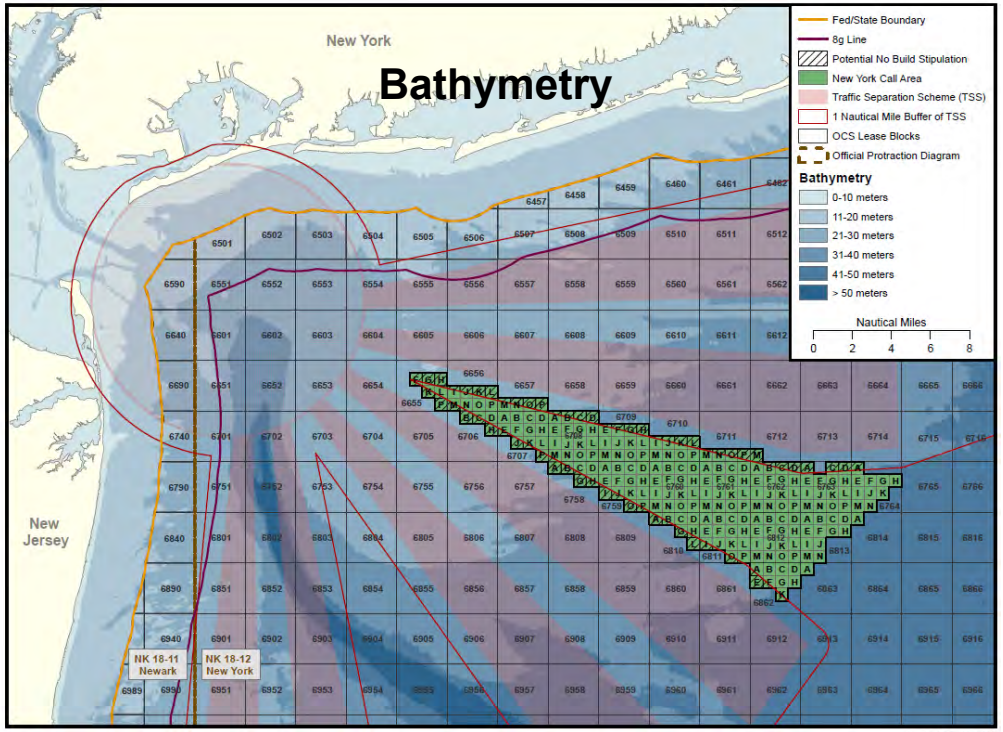
$$E_{offshore} = \overbrace{E_{An}\, E_{hn}\, E_{\phi e}}\, \underbrace{E_V\, E_d}$$

Fluid Displacement Properties

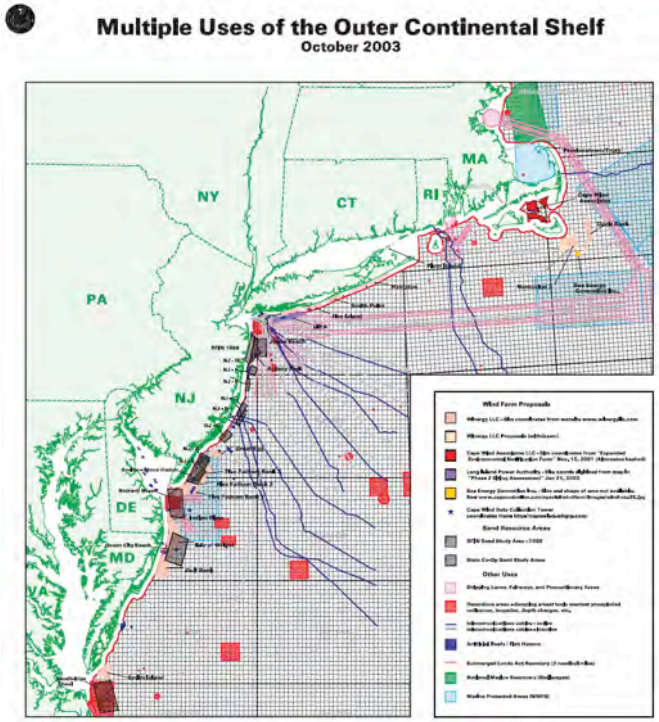
- Ultimately, use efficiency range to estimate the prospective storage resource (P_{10}, P_{50}, P_{90})

How will project objectives be achieved?

Examine risk factors that may impact storage resource estimates



Source: BOEM, 2015.



Source: BOEM, 2015.

Map shows items like marine protected areas, national marine sanctuaries, hazardous areas, telecommunication cables.

How will project objectives be achieved?

Engage stakeholders to assist future project planning and implementation

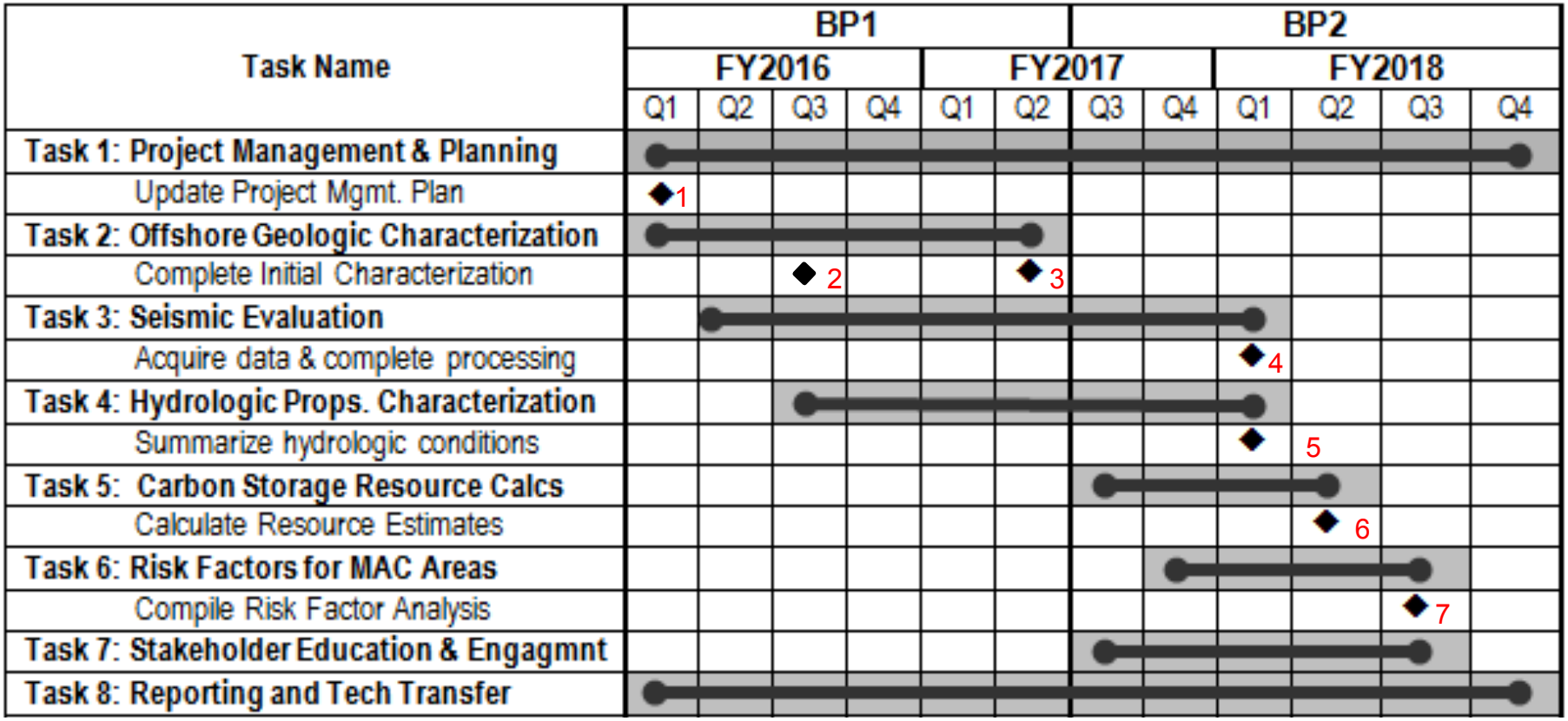
- Several workshops will be held
- Objective is to seek input for road mapping, examination of risk and other factors

MRCSP Annual Partner's Meeting, 2015

MRCSP partnership members at the East Bend Electricity Generating Station, Kentucky, to observe the geologic storage demonstration

What are the schedule and deliverables?

A lot to do within 36 months / 2 Budget Periods!



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Budget Period 1 Deliverables

Deliverable	Description
1.Project Management Plan	Updated Project Management Plan
Project Fact Sheet	Updated fact sheet for project
2. Geologic data Compilation	Itemized inventory of all sample materials and potentially usable and unique seismic data and data quality review.
Plan for additional core samples and analyses	Evaluation of geophysical logs with project partners and identification of intervals for sample analysis for hydrologic properties evaluation
3. Topical report on the Regional Stratigraphic Framework	A report summarizing key findings of the regional stratigraphic framework, including recommendations for detailed study (Interim report)

Red # = Corresponds to a milestone

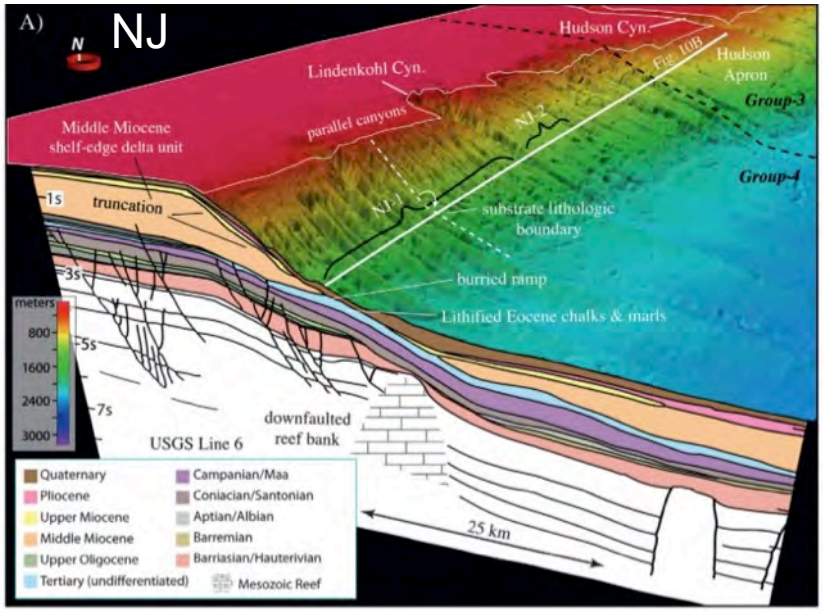
Budget Period 2 Deliverables

Deliverable	Description
5. Identification of Regional Hydrologic Boundaries	Description of significant hydrologic boundaries in the region, porosity, permeability, fluid properties, and pressure conditions, etc.
6. Topical Report on Storage Resource Estimates	A report summarizing storage resource estimates for detailed study areas, e.g. BCT, which will be extrapolated to larger regional framework to estimate storage resource across the region.
7. Summary Report on Offshore Risk Factor Analysis	Compilation of risk factor analysis, transport and infrastructure, and recommended best practices for site selection
Roadmap for future CCS projects	Compilation of research and industry views obtained during stakeholder workshops
Final Project Report	High level report summarizing CO2 resource assessment, risk factors, and stakeholder engagement activities.

What progress has been made?

Team is actively compiling and prioritizing data

- Completing the data inventory
  - Reviewing in-house data (geo surveys)
  - Digitized well logs from 10 wells drilled in Georges Bank – more to do
- Building a database to support carbon storage resource calculations and data integration
- Reviewing seismic data for data quality and selecting and prioritizing lines for additional pre-stack and post-stack processing of data
  - ~1000 line km for the first batch



USGS multibeam bathymetry surface and interpreted 2-D seismic reflection profiles of the Mid-Atlantic Margin

What does the future hold?

Stay tuned for budget period 2

- Completion of data collection and analysis
- Incorporation into the Prospective CO_2 Storage Resource calculations
- Development of clearly-defined criteria for screening potential offshore storage formations
- Uncertainty quantification specific to offshore storage environments and storage resource estimates
- Examining risk factors and hosting stakeholder workshops for road mapping

Summary

- Mid-Atlantic Offshore study area includes three major basins
- The study area is close to numerous CO_2 sources
- The project builds on work done under MRCSP and other projects
- Methodologies developed will support CO_2 storage assessment in mid-Atlantic U.S. offshore areas
- The project includes an assessment of risk, safety, and deployment factors
- Diverse and highly qualified project team ensures expansion of institutional knowledge
- The study is synergistic with other offshore projects and potential future exploration