CCS TECHNICAL DISCUSSION SERIES: SITE SELECTION

Wes Peck
Energy & Environmental Research Center
PCOR PARTNERSHIP

- Region includes:
  - Nine states.
  - Four Canadian provinces.
  - 1,382,089 mi².
- Several completed field projects.
- Bell Creek demonstration under way
- Participation in Aquistore
- More than 121 partners
ADAPTIVE MANAGEMENT APPROACH
BEST PRACTICES MANUALS

- Participated in updating several DOE best practices manuals (BPMs)
  - Site characterization
  - Risk assessment/simulation
  - Monitoring, verification, and accounting (MVA)
  - Operations
  - Outreach

- PCOR Partnership BPMs (in development)
  - Adaptive management approach
  - Site characterization
  - Modeling and simulation
  - Risk assessment
  - MVA
SITE SELECTION

- Site selection: Process of assessing potential CO₂ storage reservoir based on geologic, hydrologic, geospatial, financial, or other parameters.

- ARB is seeking information and minimum requirements that should be considered when determining whether a proposed carbon capture and storage (CCS) injection site would be suitable for permanent geologic storage of CO₂.
- ARB is looking to identify specific requirements and analysis techniques for factors necessary to ensure permanent CO₂ containment.

- Site selection is not MVA, but potential future MVA activities should be considered during the site selection process.
- Difficult, if not impossible, to engineer your way out of a bad site.
SITE SELECTION

No shortage of opinions and guidelines
BASIC REQUIREMENTS FOR SITE SELECTION

- **Big enough**
  - To accept the rates and volumes commensurate with the source(s)
- **Deep enough**
  - To ensure high-density form of CO₂ (generally >800 m)
- **Salty enough**
  - To avoid USDWs (>10,000 ppm TDS)
- **Secure enough**
  - To ensure long-term containment of the CO₂
- **Close enough**
  - To the source(s) to reduce pipeline costs
SITE SELECTION REQUIREMENTS

- Site-specific criteria matched with CO$_2$ storage needs.
- One-size does not fill all.
- If targeting a lowest common denominator, sites suitable for smaller sources/injection rates of CO$_2$ may be unnecessarily eliminated.
- Overly prescribed requirements can impede implementation.
DETERMINING INITIAL STORAGE RESOURCE

• Proper use of the DOE volumetric methodology for saline formations.
• Be aware of how much you know about the target formation.
• Don’t use the default E-factors if you have the knowledge to use a more informed E-factor.
• Dynamic storage resource will be less than the static estimate.
• Dynamic storage will eventually match the static estimate, but at very long time frames.

\[ G_{CO2} = A_t h_g \varphi_{tot} \rho E_{saline} \]
- \( A_t \) = Area
- \( h_g \) = Thickness
- \( \varphi_{tot} \) = Porosity
- \( \rho \) = Density of CO\textsubscript{2}
- \( E_{saline} \) = Efficiency factor

Knowledge of injection formation characteristics.

Knowledge of confining formation characteristics.

Identify preinjection background for characteristics such as groundwater chemistry, seismic levels, pressure/temperature conditions, etc.

Identify trapping mechanisms.

Identify potential leakage pathways.
  - Identify the amount and need for corrective action for the site.

Determine potential injectivity: planned injection rate and total injection volume.

Identify and define pressure limitations for the site.

Evaluate geomechanical response to anticipated pressures.

Evaluate hydrological response and communication in reservoir.

Perform geochemical interaction analysis.

Evaluate existing and anticipated seismic concerns.
MODELING FACTORS AND PLUME SIZE

• Define minimum modeling parameters required.
  – Will depend on the complexity of the model.
• Define acceptable limitations/uncertainties in the model used.
  – Will depend on the model and the input (GIGO).
• Model should determine how reservoir boundaries will affect the plume.
  – Important to understand the nature of the model boundaries (closed vs. open).
• Model should determine anticipated plume extent, pressure front extent, and help set AOR boundaries.
  – A requirement for Class VI well permits.
• Model should identify any areas of seismic concern.
  – Identify or incorporate?
  – NRAP’s Short-Term Seismic Forecasting (STSF)
GEOCELLULAR MODELING FACTORS

• Core analysis data (porosity and permeability)
• Well logs and formation tops (depth and thickness)
• Geologic interpretation of structural, depositional, diagenetic history of the target formation
• Seismic data (2-D and 3-D)
• Heterogeneity
• Temperature and pressure
• Footprint (geographic size vs. cell size)
DYNAMIC MODELING FACTORS

- Fluid properties (in situ and injectate)
  - Salinity
  - Viscosity
  - Density
- Relative permeability
- Boundary conditions (i.e., open, closed, semiclosed)
- Initial reservoir pressure and temperature
- Fracture pressure and regulatory relationship
- Footprint of model (grid sizes and overall model size)
- Operating objectives (rate and volume)
SITE DEVELOPMENT/LOCAL FACTORS

• Determine proximity to sources of CO₂
• Determine proximity to protected environmental areas and environmental justice communities
• Determine proximity to population centers
• Required consideration of existing resource development (impact on local aquifers, oil/gas fields, mineral resources, etc.)
LOCATION, LOCATION, LOCATION

• In an area of suitable geology
• Close to the source to minimize pipeline costs

Source: [link](http://conference.co2geonet.com/media/1051/open-forum-day-2-5_greenberg.pdf)
MINIMUM REQUIREMENTS

• Injection formation
  – Site/project specific but sufficient to meet the rates/volumes needed. If properties will not accommodate the desired rate/volume then site is unsuitable.

• Cap rock
  – Thick enough to be resolved on seismic. Often cited as >10 m.
  – Depends on lithology.
  – Extensive areal coverage.
MINIMUM REQUIREMENTS

• Existence or proximity to faults
  – Avoid if at all possible. Collect 3-D seismic data to determine degree of faulting. No extensive (long, large throw) faults in the AOR as defined by Class VI well requirements.

• How should risk factors on geologic characteristics impact monitoring requirements?
  – Should monitoring requirements impact site selection?
  – Higher risk = high-priority monitoring (type, density, frequency of monitoring).
  – Risks may be acceptable and site may be quite suitable, but higher costs for monitoring become a consideration.
CAP ROCK

- Thick enough to be resolved seismically.
- Often cited as >10 m.
- Minimum thickness dependent on lithology (salt and anhydrite vs. carbonate and shale).
- Not faulted.
- Extensive areal coverage.
- Redundant layers are a bonus.

DETERMINING SUITABILITY OF SITES BASED ON MODELING OR OTHER TECHNIQUES

• Should baseline measurements of the storage site (e.g., seismic, groundwater, soil gas, etc.) be required for judgment of site suitability?
  – No. Functionally, this is not a site selection activity.

• Should determination of CO₂ isolated by various trapping mechanisms be required?
  – No. The suitability of site should not be based on how much CO₂ may get dissolved in water or eventually mineralized.

• EPA Class VI limits injection pressure ≤90% fracture pressure. Is this good enough?
  – Yes. The Class VI pressure limitation is based on rigorous investigation and is in line with regulations in many oil/gas producing states.

• Should the ARB require more stringent AOR requirements than EPA Class VI?
  – Not sure why this would be needed.
DETERMINING SUITABILITY OF SITES BASED ON MODELING OR OTHER TECHNIQUES

• What types of models exist to help evaluate a potential CCS injection site on a geochemical, hydrological, and/or geomechanical basis? Pros/cons of each?
• How much uncertainty is common in these types of models?
  – Can be very high with geochemical models.
• How should the modeling results influence monitoring techniques?
  – Yes, but this is not a site selection metric.
SELECTION OF APPROPRIATE GEOLOGICAL STORAGE SITES

- Screening–assessing–selection
- Initial estimation of storage resource and level of uncertainty
- Awareness of subsurface competition (natural resources, pore space, etc.)
- Faulted/fractured areas not automatically out of contention
- Assessment of data gaps after screening effort
- Data availability vs. cost of new data acquisition
- Strat test well
- Geomodeling and dynamic simulation
- 2-D (good) and 3-D (really good) seismic

- Potential out-of-zone migration pathways (faults and wells)
- Legal/regulatory framework
  - Pore space ownership, AOR
THE TRADE-OFF

Potential Migration Pathways

Geologic Knowledge

Well Density

Uncertainty

Knowledge (cost)
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CONTACT INFORMATION

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

www.undeerc.org
701.777.5195 (phone)
701.777.5181 (fax)

Wes Peck
Principal Geologist
wpeck@undeerc.org
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