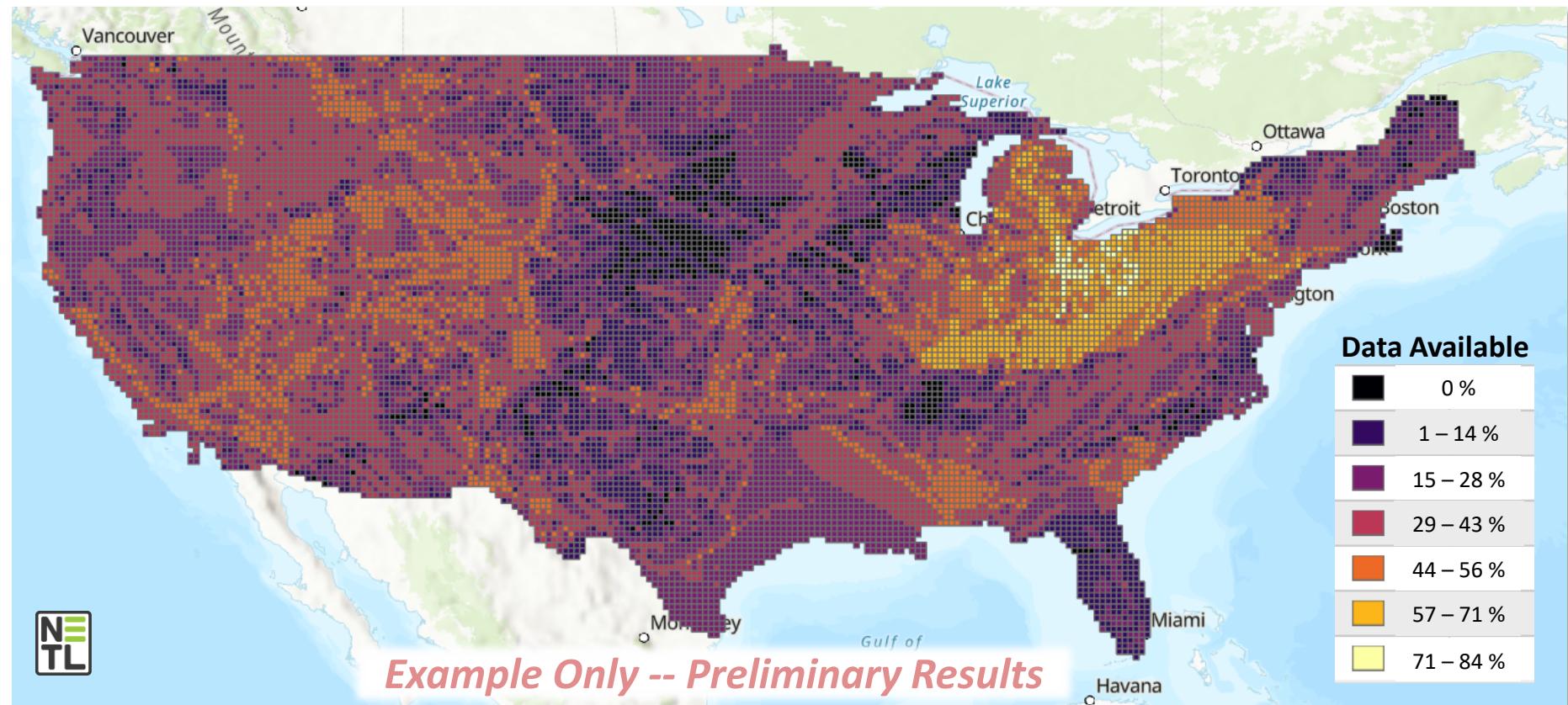


New Matrix Framework to Determine Carbon Storage Technical Viability



Julia Mulhern

NETL Support Contractor



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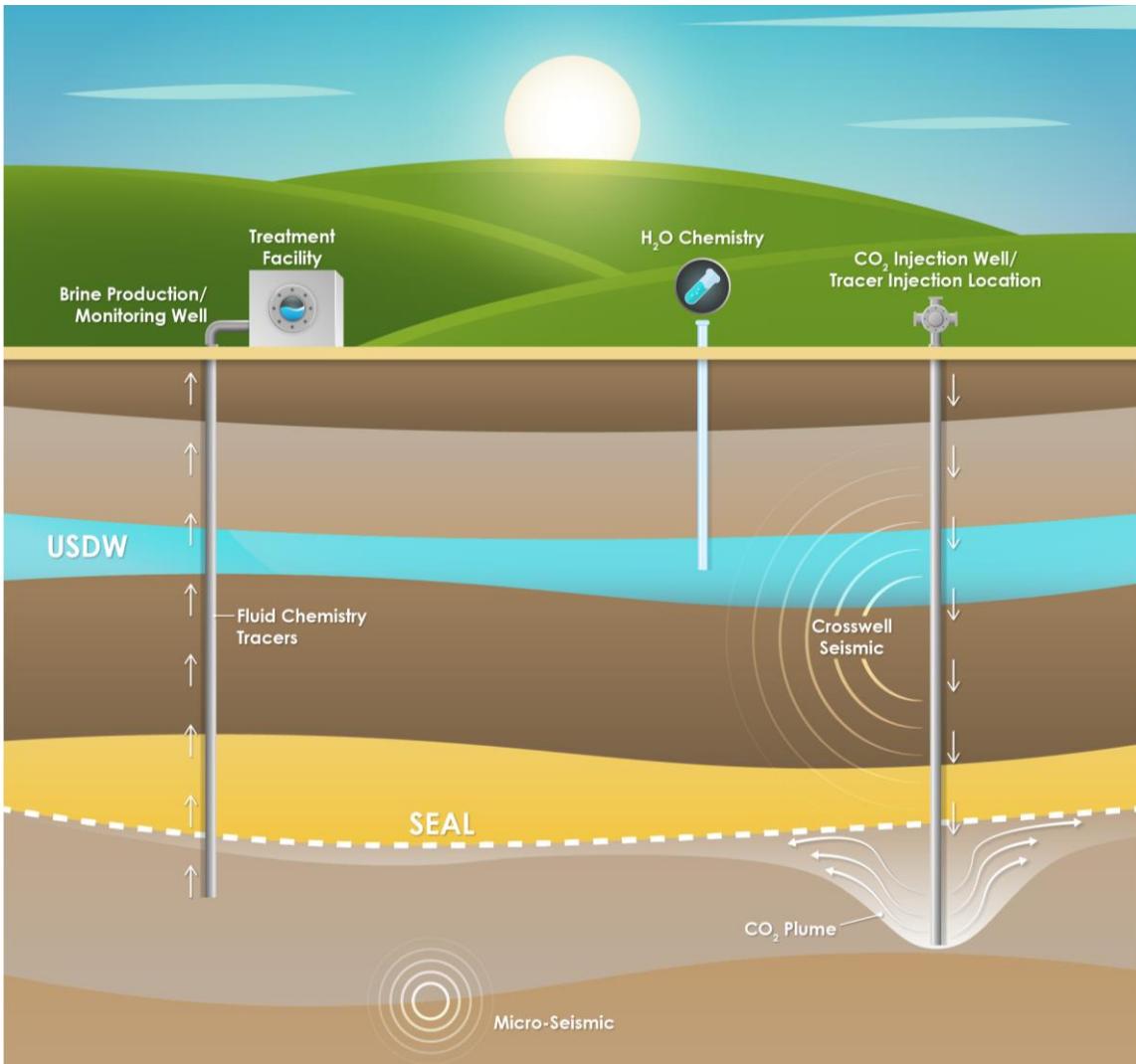
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A Comprehensive Perspective Needed for Viable GCS



GCS systems include environmental, social, socio-economic, and regulatory considerations in addition to the subsurface.



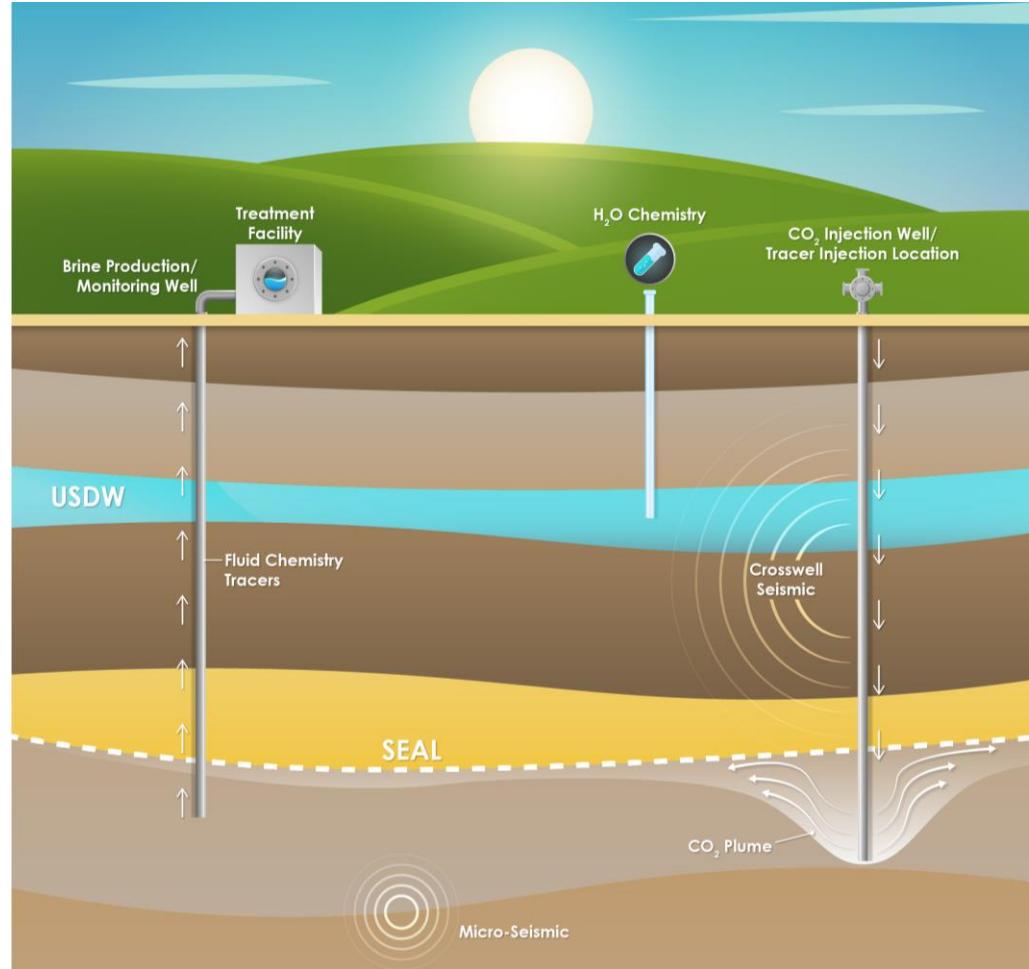
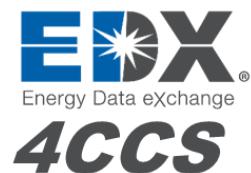
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Matrix Development for Carbon Storage Data



Motivation:

- **Need data** to inform CO₂ storage resource assessments
- Carbon storage technical viability **determined by more than geological factors:**
 - Environmental
 - Socio-economic
 - Infrastructure



What information is needed for carbon storage?

Matrix is an integrated, comprehensive knowledge framework.

Matrix Development:

1. **Review and compile** previous carbon storage assessment frameworks
2. **Integrate** existing frameworks together and add missing components/categories
3. **Review, test, and improve** framework by incorporating feedback and expert review



Reviewed Previous Carbon Storage Assessment Frameworks



Bachu, 2000

Solomon, 2006

Chadwick et al., 2008

Bachu, 2009

EPA Class VI, 2010

COMPONENT	ELEMENT	GUIDELINES FOR SITE SCREENING	
		Positive indicators	Cautionary indicators
Reservoir Data	Injection Permeability	Identify regional and sub-regional injection reservoir types. Utilize readily accessible data from public sources (e.g. state geological surveys, NATHCAR), the Regional Requirements for reservoirs, published and peer-reviewed literature, and geological maps to determine the potential for injection into the reservoir. Identify injection zone data (thickness, porosity, permeability, structural maps, information about stratigraphic setting and features that might complicate interpreting the reservoir such as stratigraphic pinchouts, faults, and fractures).	
	Adequate Depth	Assessment of minimum depth of the injection zone to prevent CO ₂ from reaching the injection zone. If depth is greater than 800 m, the well is in a supercritical state and may move more randomly through the reservoir. If depth is less than 800 m, the well is in a subsaturated state and may move more randomly through the injection zone. Wells that penetrate potential confining systems should be identified and included in the injection zone. If the injection zone is located in a faulted area, the potential for CO ₂ to move through the faulting into injection wells that may impact confining system integrity should be mapped along with potential communication pathway. Confining system integrity may be evaluated by presence of nearby hydrocarbon accumulations.	
	Confining	Candidate injection zones should be overlain by confining system comprised of one or more thick and impermeable confining zones of sufficient lateral extent to cover the projected areal extent of the injection CO ₂ plume. The injection zone should be located below the confining system to prevent CO ₂ from reaching the injection zone. Wells that penetrate potential confining systems should be identified and included in the injection zone. If the injection zone is located in a faulted area, the potential for CO ₂ to move through the faulting into injection wells that may impact confining system integrity should be mapped along with potential communication pathway. Confining system integrity may be evaluated by presence of nearby hydrocarbon accumulations.	
	Prospective Resources	Candidate CO ₂ storage reservoirs should contain enough prospective storage resources beneath a robust confining system for the volume of CO ₂ estimated during Project Definition and the depleted fluid volume of the reservoir. The prospective resources should be located beneath a robust confining system and sub-regional scale utilizing existing data (e.g. NATHCAR), and state geological surveys to populate basic numerical models.	
Regional Data	Protected and Sensitive Areas	Identify environmentally sensitive areas using U.S. Environmental Protection Agency, U.S. Department of Energy, U.S. Forest Service and U.S. Bureau of Land Management (BLM) systems. Assess the potential for conflicts with utility, pipeline routes, field compressors and injection wells. In addition, evaluate potential conflicts with other sensitive settings for other hazards (e.g. flood, landslide, tsunami).	
	Protection and Recovery	Identify prospective areas using state and federal laws. Assess the potential for conflicts with existing resource development, including wells that penetrate the confining system, using data from state and federal oil and gas, coal, mining and UIC and natural resource management offices. Assess the potential for conflicts with utility, pipeline routes, field compressors and injection wells. In addition, evaluate potential conflicts with other sensitive settings for other hazards (e.g. flood, landslide, tsunami).	
	Existing Resource Development	Identify all pipelines and gathering linesystems. Assess potential for conflicts in routing of pipelines to injection wells. Identify all existing wells, including oil and gas wells, geothermal wells, and wells for monitoring, identify other ROWs (e.g. pipelines, BBL pipelines) and assess potential for synergies or conflicts in utilizing existing storage projects. Thorough care can be found through commercial and government sources.	
	Pipeline ROWs	Identify all pipelines and gathering linesystems. Assess potential for conflicts in routing of pipelines to injection wells. Identify all existing wells, including oil and gas wells, geothermal wells, and wells for monitoring, identify other ROWs (e.g. pipelines, BBL pipelines) and assess potential for synergies or conflicts in utilizing existing storage projects. Thorough care can be found through commercial and government sources.	
Local Data	Demographic Trends	Describe communities closest to and most susceptible SAs by evaluating nearby population, demographic trends, and other characteristics. Identify other areas that may be susceptible to CO ₂ migration and develop an understanding of the areal extent and spatial trends, and begin to identify opinion leaders.	
	Local Industrial and Environmental History	Describe the history of land use, industrial development and environmental impacts to communities closest to and most susceptible SAs by evaluating sources such as online media sites, regulatory agencies, corporate websites, local environmental groups/websites, and other sources. Begin to assess community sensitivity to land use and the environment.	
	Complete Site Screening	Selected Area: Develop a list of potential selected Areas and rank based on criteria established in Project Definition.	

Table 1. Guidelines for Site Screening evaluation for Elements within each Component.

Rodosta et al., 2011

Kaldi et al., 2008

Table 6: Criteria for screening sedimentary basins within a country or state for geological storage of CO₂ (modified from Bachu, 2003).

Criterion	Increasing CO ₂ Storage Potential				
	1	2	3	4	5
1. Seismicity (tectonic setting)	Very high (e.g. subduction)	High (e.g. syn-rift, strike-slip)	Intermediate (e.g. foreland)	Low (e.g. passive margin)	Very low (e.g. cratonic)
2. Size	Very small (< 100 km ²)	Small (1000–5000 km ²)	Medium (5000–25000 km ²)	Large (25000–100000 km ²)	Very large (> 100000 km ²)
3. Depth	Very shallow (< 300 m)	Shallow (300–800 m)	Intermediate (800–3500 m)	Deep (3500–8000 m)	Very deep (> 8000–35000 m)
4. Faulting intensity	Extensive	Extensive	Intermediate	Low	Moderate
5. Hydrogeology	Extensive flow systems, or compaction flow	Extensive flow systems	Intermediate	Low	Limited
6. Geothermal	Warm basin (> 30°C/km)	Moderate (30–40°C/km)	Moderate (30–40°C/km)	Cold basin (< 30°C/km)	
7. Reservoir-seal pairs	N	N	N	N	
8. Coal seams	N	N	N	N	
9. Coal rank	A	B	C	D	
10. Evaporites	N	N	N	N	
11. Hydrocarbon potential	N	N	N	N	
12. Maturity	U	U	U	U	
13. Onshore/offshore	D	D	D	D	
14. Climate	A	A	B	C	
15. Availability	B	B	C	D	
16. Infrastructure	N	N	N	N	

Table 1
Thresholds used for the pre-screening of CO₂ storage options in The Netherlands.

Parameter	Threshold
Capacity	>4 Mt for gas/oil and ≥2 Mt for aquifers ^a
Thickness reservoir	>10 m
Depth top reservoir	≥800 m
Porosity reservoir	Aquifers: >10%
Permeability reservoir	Aquifers: an expected permeability of 200 mD or more ^b
Thickness seal	≥10 m. Both simple seals as well as complex caprock have been taken into account ^c
Seal composition	Salt, anhydrite, shale or claystones
Reservoir composition	Aquifers: sandstones, hydrocarbon fields: limestone, sandstone, siltstone, carbonates
Initial pressure	Overpressure areas excluded
Salt domes	Relevant for aquifers. Traps located alongside/near salt domes/walls have been excluded because there is a high risk of salt cementation

Rameriz et al., 2010

Delprat-Jannuad et al., 2013

Consideration	Desirable	Screening Threshold		Notes
		Suggested boundary condition	Notes	
Depth	> 1000 m	below local fresh water aquifers	CO ₂ must be stored below fresh water aquifers and it is highly unlikely to move into them. The CO ₂ plume will be limited by the reservoir temperature and pressure, but it is generally >800-1000m. Additional storage offers potential additional security.	
Reservoir pressure	< hydrostatic	not greater than hydrostatic	See graph for estimated capacity based on produced volumes; reservoir capacity adds a margin of safety. Note also that fields with higher pressure may have lower permeability.	
Capacity	25–50% project requirements	project requirements	See graph for estimated capacities; note that injection rate can also be limited by injection wells and/or horizontal wells, at the expense of cost.	
Injectivity	25–50% project requirements	project requirements		

Parameter	The screening criterion proposed for the CO ₂ storage by Chadwick et al. (2008)	
	Positive indicators	Cautionary indicators
Total storage capacity	Total capacity of reservoir estimated to be much larger than the total amount produced from the CO ₂ source	Total capacity of reservoir estimated to be similar or less than the total amount produced from the CO ₂ source
Depth	>1000 m	<200 m
Thickness (net)	>50 m	<20 m
Porosity	>20%	<10%
Permeability	>100 mD	<10 mD
Salinity	>100 g/L	<30 g/L
Seal properties		
Leakage		
Un-faulted		
country		
Thickness	>100 m	<20 m
Capillary entry pressure	Math greater than buoyancy force of maximum produced CO ₂ column height	

Parameter	Threshold	Notes
Capacity	>4 Mt for gas/oil and ≥2 Mt for aquifer	
Thickness reservoir	>800 m	
Depth top reservoir	>10 m	
Reservoir porosity	Aquifers: an expected permeability of 200 mD or more	
Thickness seal	>10 m. Both simple seals as well as complex seal have been taken into account	
Seal composition	Salt domes, sandstones, hydrocarbon fields: limestone, sandstone, siltstone, carbonates	
Initial pressure	Overpressure excluded	
Salt domes	Relevant for aquifers. Traps located alongside/near salt domes/walls have been excluded because there is a high risk of salt cementation	

Raza et al., 2016

Table 1
Site screening criteria for depleted reservoirs. Detailed descriptions of each criterion can be found in the Supplementary Material.

Category	Criteria	Disqualifying Threshold
Capacity and Injection Optimization	Depth to Top of Formation	<800 m
	Permeability	<10mD
	Porosity	<10%
	Reservoir Thickness	<10 m
	Minimum Storage Capacity	< minimum capacity needed for project
	Secondary Confining	No secondary confining unit
Retention and Geomechanical Risk Minimization	Top Seal Thickness	<25 m
	Active/Inactive Faulting	Fault active in the Quaternary distance from closest injection well <3 km
	Earthquake Record	M ≥ 3 (epicenter < 10 km) & M ≥ 3 (epicenter < 5 km) to pressure front
	Bottom Seal/potential for pressure transmission to the base/mass	No bottom seal
Siting and Economic Constraints	Yes	
Public Health & Safety, Regulators & Stakeholders	Critical wildlife habitats for certain species and wilderness study areas	
	Population Density for depleted fields are inactive	> 75 people/km ²
	Restricted Lands for depleted fields are inactive	National landmarks, conservation lands, military installations, American Indian Lands, Federal Lands and State Lands
	Maximum Depth to Top of Formation	>10,000 ft (3,040 m)
	Water Depth (if offshore)	>5000 ft (1524 m)

Table 1
Qualifying thresholds for storage sites in this study. Modified from Callas et al. (2022) and Kim et al. (2022).

Category	Geological parameter	Qualifying threshold
Storage Optimization	Storage resource (high estimate)	> 3 MtCO ₂ (OG field)
	Depth (to top of formation)	> 800 m
	Permeability	> 10 mD (mean)
	Porosity	> 10% (mean)
	Reservoir Thickness	> 10 m (mean)
	Secondary confining	Exist one layer, > 10 m
Risk minimization	Salinity	> 10,000 ppm (TDS): Saline formation only
	Top seal thickness	> 25 m: Saline formation only
Others	Offshore location	Consider only onshore location

Callas et al., 2022

Bump et al., 2022

Alcalde et al., 2021

Rameriz et al., 2010

Delprat-Jannuad et al., 2013

Kim et al., 2022, 2023

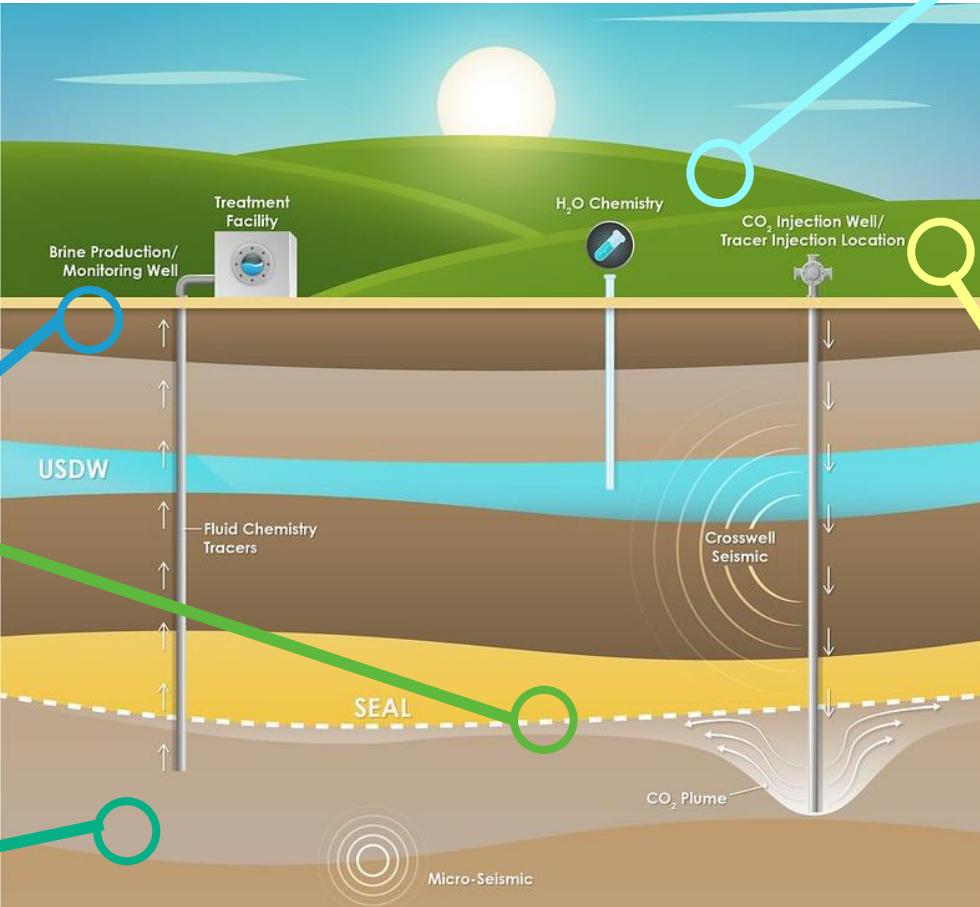
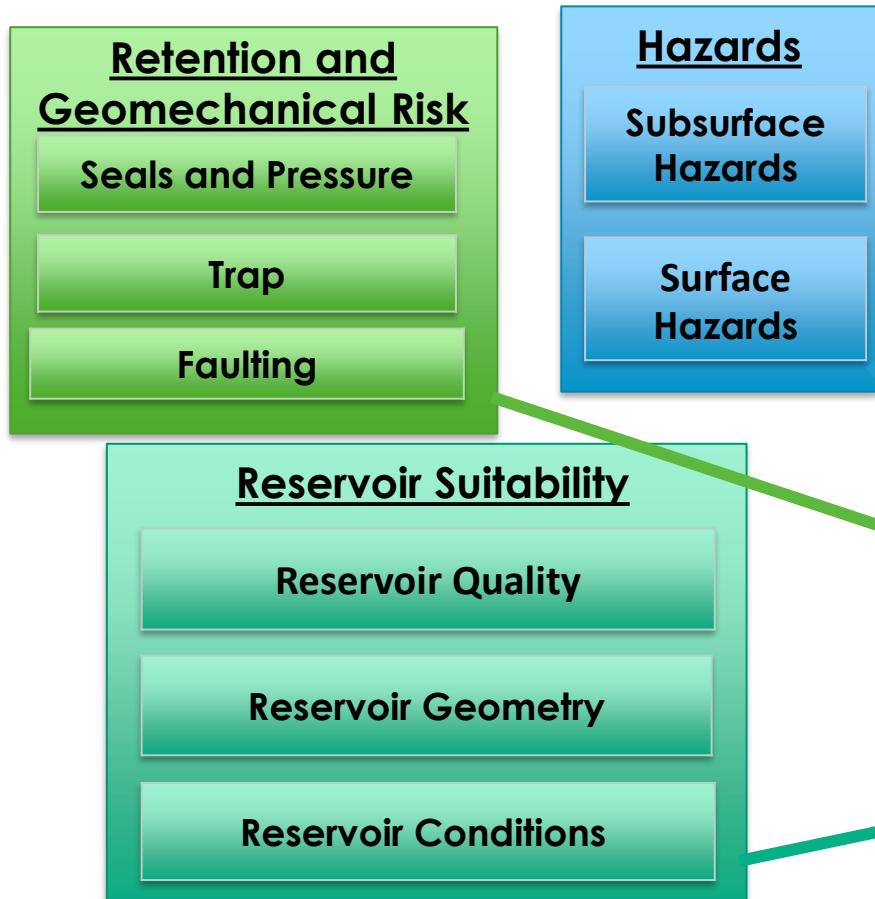


Matrix Framework Carbon Storage Technical Viability



5 Categories ➔ 14 Subcategories

- Reflects **multidisciplinary requirements** of carbon storage projects



Environmental Justice, Social Justice, and Community Impacts

Community Sentiment

Impact on Community

Siting, Regulatory, and Jurisdiction Considerations

Land Rights/Use

Population and Habitats

Jurisdiction

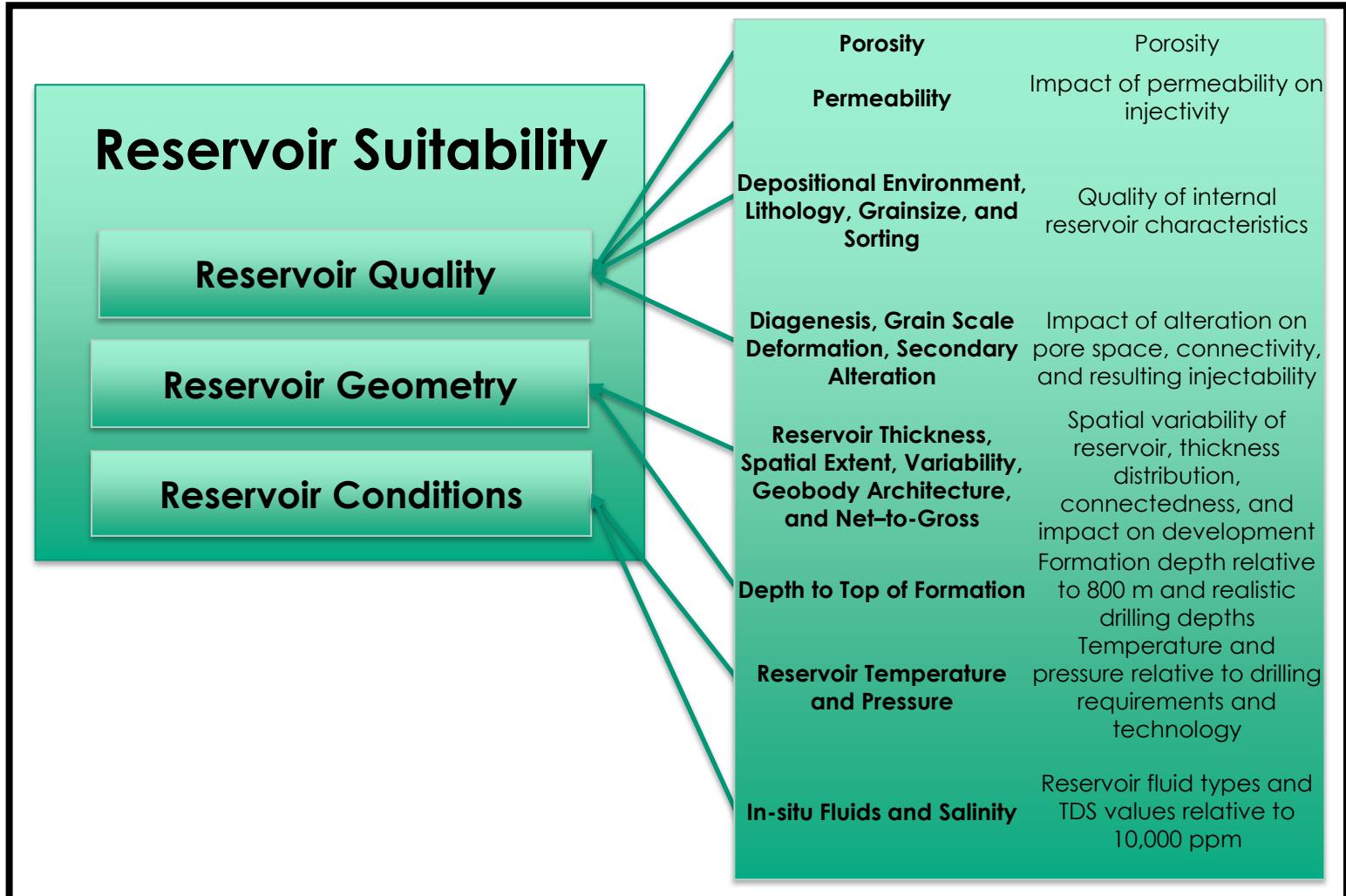
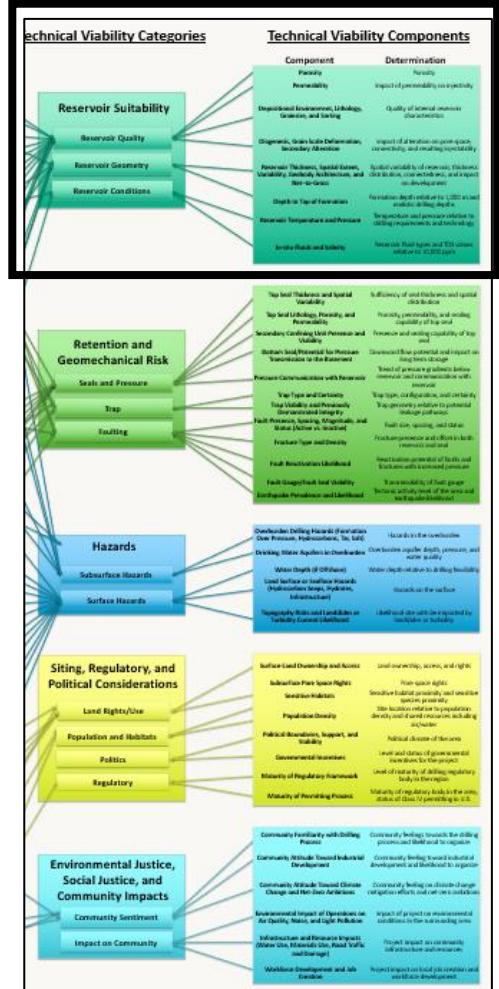
Regulatory



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Matrix has Three Levels of Granularity

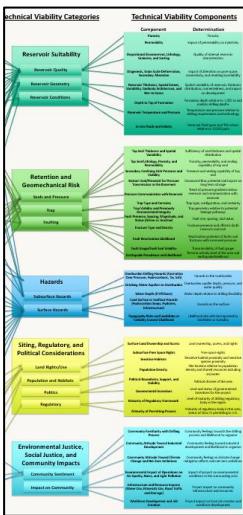
5 Categories → 14 Subcategories → 46 Components



Comprehensive Matrix Includes Viability Designations



- Build upon previous studies (e.g., **Rodosta et al., 2011**) to define criteria
- Components of technical viability are described for designations ranging from “Non-Viable to Excellent Viability”
- **Viability designations help evaluate data utility**



Viability designations assigned at the component level.

Categories	Subcategories	Components	Designation	Non-Viable	Possibly Non-Viable	Viable with Hurdles	Viable but Non-Ideal	Fair / Decent Viability	Good Viability	Excellent Viability	Unknown Viability
		Specific Component	Determination	This component would prevent the project from moving forward or cause it to terminate early.	This component would make the project non-economic, reduce its lifespan, or reduce total injection capacity.	This component will be detrimental to the project but can be overcome with time and/or money.	This component is not well suited for sequestration, but likely will not be prohibitive to the project moving forward.	This component is not optimal, but should be sufficient.	This component is well-suited for this project.	The component is ideal, optimized, and/or desirable for this project.	There are insufficient data to assess this component, therefore viability is unknown.
	Reservoir Quality	Reservoir Porosity	Porosity	Limited porosity.	Limited permeability will prevent injectivity.	Low porosity.	Low to moderate porosity.	Moderate porosity.	Good porosity.	Excellent porosity.	Unknown porosity.
		Reservoir Permeability	Impact of permeability on injectivity.	Quality of internal reservoir characteristics.	Poor internal reservoir characteristics.	Low permeability will decrease injectivity.	Moderate permeability.	Good permeability.	Excellent permeability.	Unknown permeability.	Unknown permeability.
		Depositional Environment, Lithology, Grainsize, and Sorting	Diagenesis, Grain Scale Deformation, Secondary Alteration, Reservoir Fractures	Impact of alteration and reservoir fractures on pore space, connectivity, and resulting injectability.	Alteration that eliminates pore space and connectivity. Fractures decrease permeability enough to prevent injection.	Alteration and fracture density eliminates some pore space and connectivity.	Some alteration and fractures impacting pore space and connectivity.	Little alteration and fracturing detrimentally impacting pore space.	Reservoir has very good consistency and very limited variability.	Reservoir thickness and spatial extent variability is unknown.	Alteration level, extent, fracture density, and impact are unknown.
	Reservoir Geometry	Reservoir Thickness Distribution, Spatial Extent, and Lateral Variability	Spatial variability of reservoir, thickness distribution, connectedness, and impact on development.	Reservoir has highly variable spatial extent and thickness, with disconnected areas preventing development.	Reservoir has highly variable spatial extent and thickness, with some potential disconnected areas.	Reservoir has somewhat variable spatial extent and thickness with some potential disconnected areas.	Reservoir has variable spatial extent and thickness away from the main reservoir body with minor potential disconnected areas.	Reservoir has variable spatial extent and thickness away from the main reservoir body.	Reservoir has fairly consistent thickness and limited variability.	Reservoir has very good consistency and very limited variability.	Reservoir internal architecture and variability is unknown.
		Reservoir Internal Variability, Geobody Architecture, and Net-to-Gross	Reservoir internal variability, including geobody architecture and net-to-gross impact storage volume and developability.	Reservoir highly variable internally and geobody architecture will prevent development.	Reservoir has somewhat variable and unconstrained internal architecture.	Reservoir has moderate internal variability.	Reservoir internal architecture is favorable for development.	Reservoir internal architecture is well constrained and favorable for development.	Reservoir internal architecture is well constrained and favorable for development.	Reservoir internal architecture is well constrained and favorable for development.	Reservoir internal architecture and variability is unknown.
		Depth to Top of Formation	Formation top depth relative to 800 m, which is the depth at which CO2 enters supercritical state. As well as realistic drilling depths.	Formation top above 800 m or below realistic drilling depth (>20,000 ft).	Formation top below 800 m but potentially too deep for realistic drilling (>20,000 ft).	Formation top below 800 m but deep enough to cause potential drilling issues.	Formation top below 800 m but deeper than ideal for the area.	Formation top below 800 m and within reasonable reach for drilling.	Formation top below 800 m and within reasonable reach for drilling.	Formation top depth uncertain.	Formation top depth uncertain.
	Reservoir Conditions	Reservoir Temperature	Reservoir temperature relative to drilling requirements and technology.	Too high temperature for feasible development.	Temperatures at the limits of development.	Temperatures high enough to require HTHP equipment.	Temperatures are high but no HTHP equipment required.	Temperatures are high but no HTHP equipment required.	Temperatures in reasonable range.	Temperatures unknown.	Temperatures unknown.
		Reservoir Pressure	Reservoir pressure relative to drilling requirements and technology.	Too high pressure for feasible development.	Pressure at the limits of development.	Pressures high enough to require HTHP equipment.	Pressures are high but no HTHP equipment required.	Pressures are high but no HTHP equipment required.	Pressures in reasonable range.	Pressures unknown.	Pressures unknown.
		In-situ Fluids, Salinity, and CO2 Density	Reservoir fluid types and TDS values relative to 10,000.	TDS too low, considered aquifer.	TDS near or slightly above the 10,000 PPM threshold. Composition not clearly potable; could warrant aquifer exemption under 40 CFR § 146.4.		Saline reservoir fluid over 10,000 TDS or hydrocarbon reservoir fluids.	Saline reservoir fluid over 10,000 TDS or hydrocarbon reservoir fluids.	Reservoir fluids unknown.	Reservoir fluids unknown.	Reservoir fluids unknown.
	Seals and Pressure	Proven / Demonstrated Effectiveness of Top Seal	Seal layer proven or demonstrated effectiveness either in situ or analogously.	Top seal proven ineffective.	Top seal previous effectiveness not tested.	Top seal has demonstrated sealing capabilities.	Top seal has demonstrated sealing capabilities against over pressure.	Top seal has demonstrated sealing capabilities against over pressure.	Top seal has demonstrated sealing capabilities against over pressure.	Top seal effectiveness uncertain.	Seal effectiveness uncertain.
		Top Seal Thickness and Spatial Variability	Sufficiency of seal thickness and spatial extent.	Seal is insufficiently thick or has insufficient spatial extent.	Seal may be insufficiently thick or have insufficient spatial extent.	Top seal has sufficient thickness and spatial extent with some transmissibility but will hold CO2, its previous effectiveness may be unknown.	Top seal has sufficient thickness and spatial extent and is likely effective.	Seal has excellent thickness and spatial extent and is proven effective.	Seal has excellent thickness and spatial extent and is proven effective.	Seal thickness, spatial extent, and effectiveness are unknown.	Seal thickness, spatial extent, and effectiveness are unknown.
		Top Seal Viability, Fracture Pressure, Lithology, Porosity, and Permeability	Porosity, permeability, lithology, CO2 breakthrough pressure, and sealing capability of top seal.	Top seal is too porous and too permeable to be effective.	Top seal has some issues with porosity and permeability but may be sufficient.		Top seal has sufficient sealing capability.	Seal has excellent sealing properties, and is proven effective.	Seal characteristics are unknown.	Seal characteristics are unknown.	Seal characteristics are unknown.
		Secondary Confining Unit Presence and Viability	Presence and sealing capability of top seal.	No secondary confining unit and overburden highly porous and likely to flow easily.	Layers in the overburden have not necessarily secondary confining units but could have some sealing potential.	Secondary confining unit is present.	Secondary confining unit is present, has a sealing lithology, and is relatively thick.	Thick secondary confining seal with proven viability in injection location.	Presence of secondary confining seal unknown.	Presence of secondary confining seal unknown.	Presence of secondary confining seal unknown.

Manuscript in prep:

Mulhern, J., Mark-Moser, M., Creason, C.G., Cordero Rodriguez, N. in prep.
An Integrated Framework for Geologic Carbon Storage Viability Assessments

Using the CS TVA Matrix

- **Data availability assessment** – a machine learning centered workflow which is currently in development by the NETL team to perform spatial data gaps assessments (Creason et al., next talk)
- **Data gaps assessment** – matrix framework provides an organization framework for reviewing available data at various spatial scales
- **Framework for geologic modeling** – considerations and quantitative boundaries compiled with the matrix serve as a guide for model development

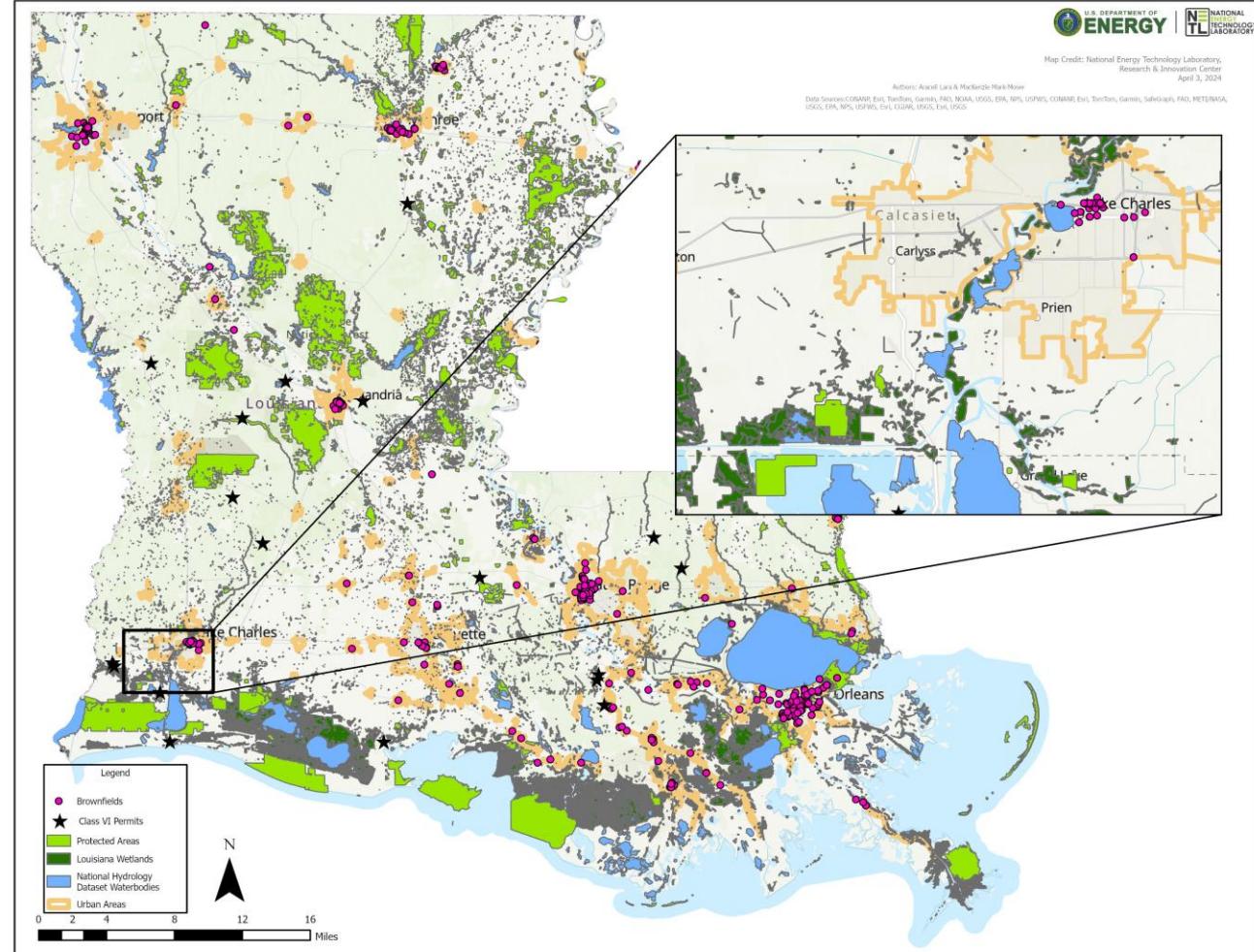


Retention and Geomechanical Risk					
Sub-Cat	Components	Gulf of Mexico	Atlantic	Pacific	Alaska
Seals and Pressure	Proven/Demonstrated Effectiveness of Top Seal	Some aggregated well data and regional geologic interpolations of seal properties exist. Included in some interpretations of nationwide datasets.	Understanding of seals limited by sparse drilling and seismic data for the region.	Seals mapped in regions where oil and gas exploration has taken place.	
	Top Seal Thickness and Spatial Variability				
	Top Seal Viability, Fracture Pressure, Lithology, Porosity, and Permeability				
	Secondary Confining Unit Presence and Viability				
	Bottom Seal, Downward Flow, and Induced Seismicity				
	Pressure Communication with Reservoir				
Trap	Geological Trap Type and Certainty	Aggregated data on traps available. Some information can be garnered from existing hydrocarbon field information.	Limited data on traps for the region based on limited subsurface mapping.	Some information can be garnered from existing hydrocarbon field information.	
	Trap Viability and Previously Demonstrated Integrity				
Faulting	Fault Presence, Depth, Spacing, Magnitude, Status (Active vs. Inactive)	Mapped faults from USGS. Some earthquake occurrence data aggregated.	Mapped faults from USGS. Some earthquake occurrence data aggregated.	Mapped faults from USGS. Some earthquake occurrence data aggregated.	
	Fracture Type and Density				
	Fault Reactivation Likelihood with Increased Pressure				
	Fault Gouge and Cementation/Fault Seal Viability				
	Earthquake Prevalence and Likelihood				

Mulhern, J. S.; Mark-Moser, M., Rose, K. Offshore Geologic Carbon Storage Data Collection and Data Gaps Analysis; DOE/NETL-2024-4804; NETL Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Albany, OR, 2024; p 24. <https://doi.org/10.2172/2382659>

Benefits of a Comprehensive Approach

- Integrated matrix framework ensures that multi-faceted aspects of carbon storage are considered up front
- Creates a starting point for those new to geologic carbon storage
- Ensures that stakeholders consider project aspects which may be outside of their primary discipline



Acknowledgements



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List of References Related to this Project



CS TVA Matrix:

Mulhern, J.S., Mark-Moser, M., Creason, C.G., Cordero Rodriguez, N., Shay, J., Lara, A., and Rose, K., in prep. Carbon Storage Technical Viability Matrix: A Framework for Conceptualization and Analysis. *Frontiers in Energy*.

Mulhern, J.S., Mark-Moser, M., Creason, C.G., Cordero Rodriguez, N., Shay, J., Lara, A., and Rose, K. Carbon Storage Technical Viability Approach (CS TVA) Matrix: Integrating Multiple Components for Comprehensive Scoping. Geological Society of America Connects Annual Meeting. Anaheim, CA. September 22-25, 2024. Oral presentation (this talk).

CS TVA Database:

Mulhern, J.S., Shay, J., Cordero Rodriguez, N., Creason, C.G., Mark-Moser, M., Lara, A., Rose, K., Carbon Storage Technical Viability Approach (CS TVA) Database, 6/11/2024, <https://edx.netl.doe.gov/dataset/edx4ccs-carbon-storage-technical-viability-approach-database>, DOI: 10.18141/1984655.

CS TVA Workflow:

Creason, C.G., Mulhern, J.S., Cordero Rodriguez, N., Mark-Moser, M., Lara, A., Shay, J., and Rose, K. Where are the Data? Automating a Workflow for Carbon Storage Data Gap Analysis, Geological Society of America Connects Annual Meeting. Anaheim, CA. September 22-25, 2024 (following talk).

Creason, C.G., Mulhern, J.S., Cordero Rodriguez, N., Mark-Moser, M., Lara, A., Shay, J., and Rose, K. Where are the Data? Automating a Workflow for Carbon Storage Data Gap Analysis, FECM / NETL Carbon Management Research Project Review Meeting. Pittsburgh, PA. August 5-9, 2024.

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