GEESS as a Mechanism to Facilitate the Commercialization of Geologic Carbon Sequestration

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NETL support contractors

2023 FECM / NETL Carbon Management Research Project Review Meeting

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Project Overview

Geoanalytical Economic Evaluation of Saline Storage (GEESS) project objectives are to:

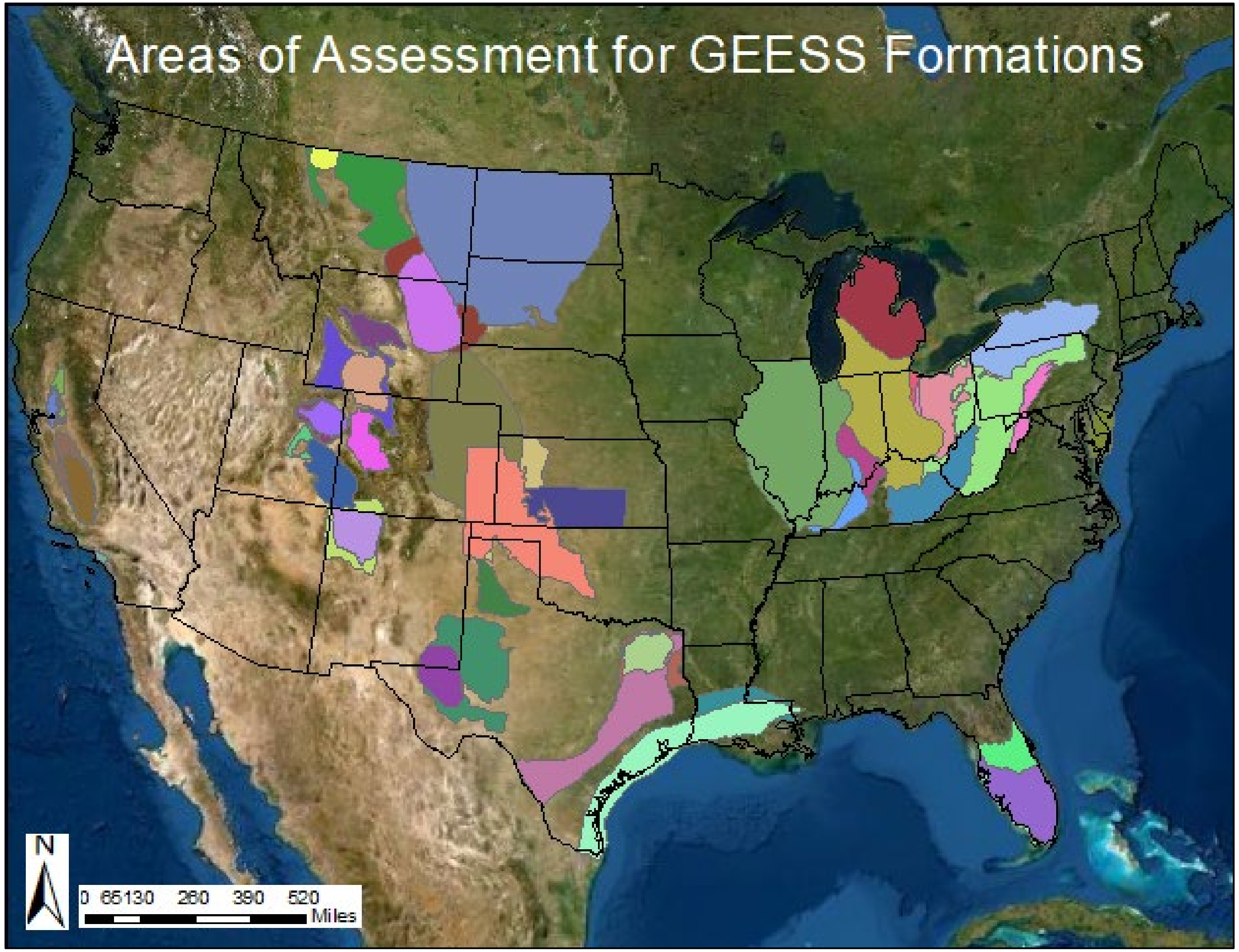
- Characterize in detail geologic saline formations targeted for geologic carbon sequestration (GCS) using publicly available datasets
- Create high spatial resolution datasets (up to 5 km grid) of geologic parameters
- Provide a comprehensive list of references used to characterize each geologic formation

Key Project Participants:

- Darren Damiani (Fossil Energy/Carbon Management, Department of Energy)
- Tim Grant and Dave Morgan (National Energy Technology Laboratory)
- Jeffrey Eppink and Austin Mathews (NETL Site Support Contractors)

Project Performance Dates: May 1, 2023 – March 31, 2024 (current task)

Project Background

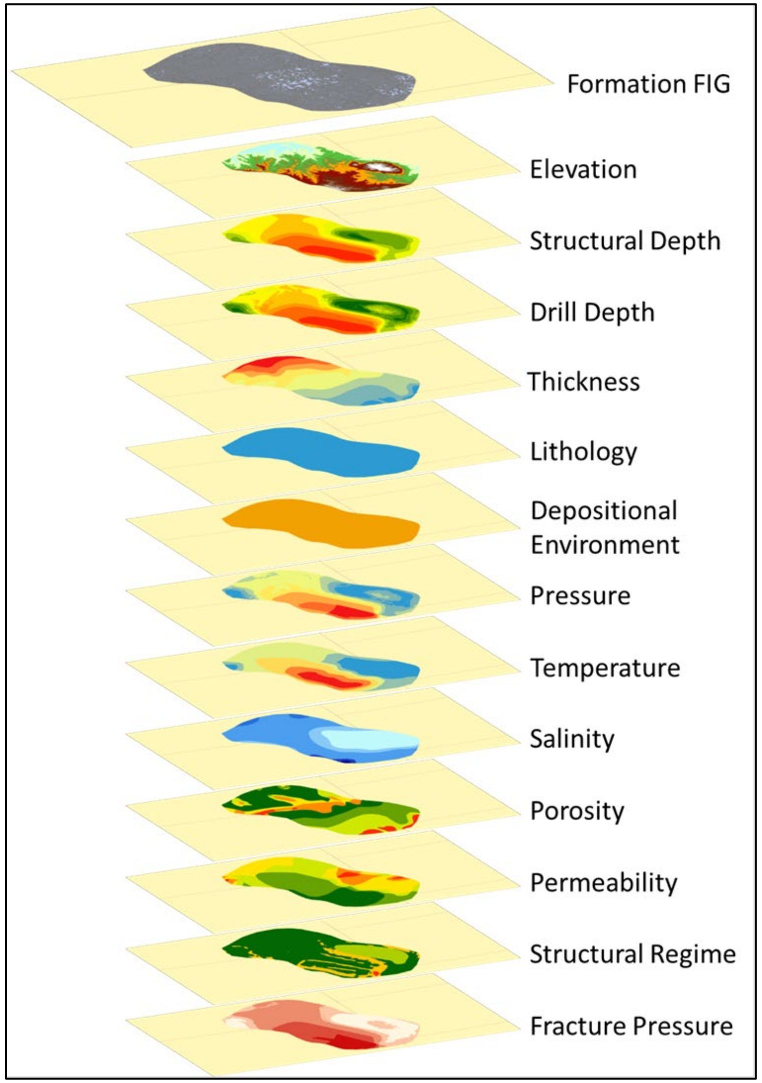


- GEESS characterizes 57 geologic saline formations targeted for GCS in major sedimentary basins across the U.S.
- Formations are chosen for their geographic and geologic diversity
- GEESS's objective is to provide a comprehensive assessment of CO_2 sequestration opportunities in saline formations across the lower 48 states

Background

➢ **GEESS Phases:**
- Phase 1: model design and construction
- Phase 2: 15 geologic formations integrated
- Phase 3: 25 additional geologic formations integrated
- Phase 4: 17 additional formations integrated; all formations updated with additional attributes including porosity, permeability, salinity, structural regime, temperature, and pressure
- Phase 5 (current):
  - Addition of formation fracture pressure to database
  - Comparison with NETL's CO2_S_COM and determination of optimal grid spacing

➢ **GEESS supports DOE's research and development program, specifically the CO2_S_COM database.**



Technical Approach/Project Scope

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Project Execution Plan

- Task 12a – Assess fracture pressure for each geologic formation
- Task 12b – Compare GEESS datasets with current CO2_S_COM

Project Schedule

- Task 12a – Deliver list of references at end of October 2023; deliver spatial database at end of March 2024
- Task 12b – Deliver report detailing comparison of GEESS and CO2_S_COM in March 2024

Project Expected Outcomes

- Task 12a – Updated spatial database that includes fracture pressure estimates for 57 U.S. geologic formations, as well as a list of the references used to perform the analysis
- Task 12b – Report with maps and tables to discern differences between GEESS and CO2_S_COM datasets

Project Risks

- Lack of public domain data and biases therein (legacy data often come from O&G reservoirs)

To mitigate the risks due to lack of data, innovative methodologies are being developed including:

- In-depth research and examination of case study data
- Prediction algorithms (i.e., Eaton equation for formation fracture pressure)
- Analogs

Project Status and Accomplishments – Task 12a

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- **Status of Project Objectives: on target**
- **Significant Accomplishments:**
  - Through Phase 4 and into Phase 5, 57 geologic formations are characterized with the following parameters:

GEESS Phase 5 Data Fields		
Formation Number	Grid Pt. Long. (degrees)	Permeability: Maximum (mD)
Formation Identifier	Grid Pt. Lat. (degrees)	Salinity (mg/L)
Formation Name	Depth - top (ft)	Dome Structure (%)
State	Thickness (ft)	Anticline Structure (%)
Basin	Formation Pressure (psi)	5 Degree Incline (%)
Regional Carbon Sequestration Partnership	Formation Temp (deg F)	10 Degree Incline (%)
Reservoir Type (saline vs. brackish)	Porosity: Best Estimate (%)	Flat Structure (%)
Lithology	Porosity: Minimum (%)	Fracture Pressure: Best Estimate (psi)*
Depositional Environment	Porosity: Maximum (%)	Fracture Pressure: Minimum (psi)*
Geologic Age	Permeability: Best Estimate (mD)	Fracture Pressure: Maximum (psi)*
Area of Analysis (sq mi)	Permeability: Minimum (mD)	

*In progress

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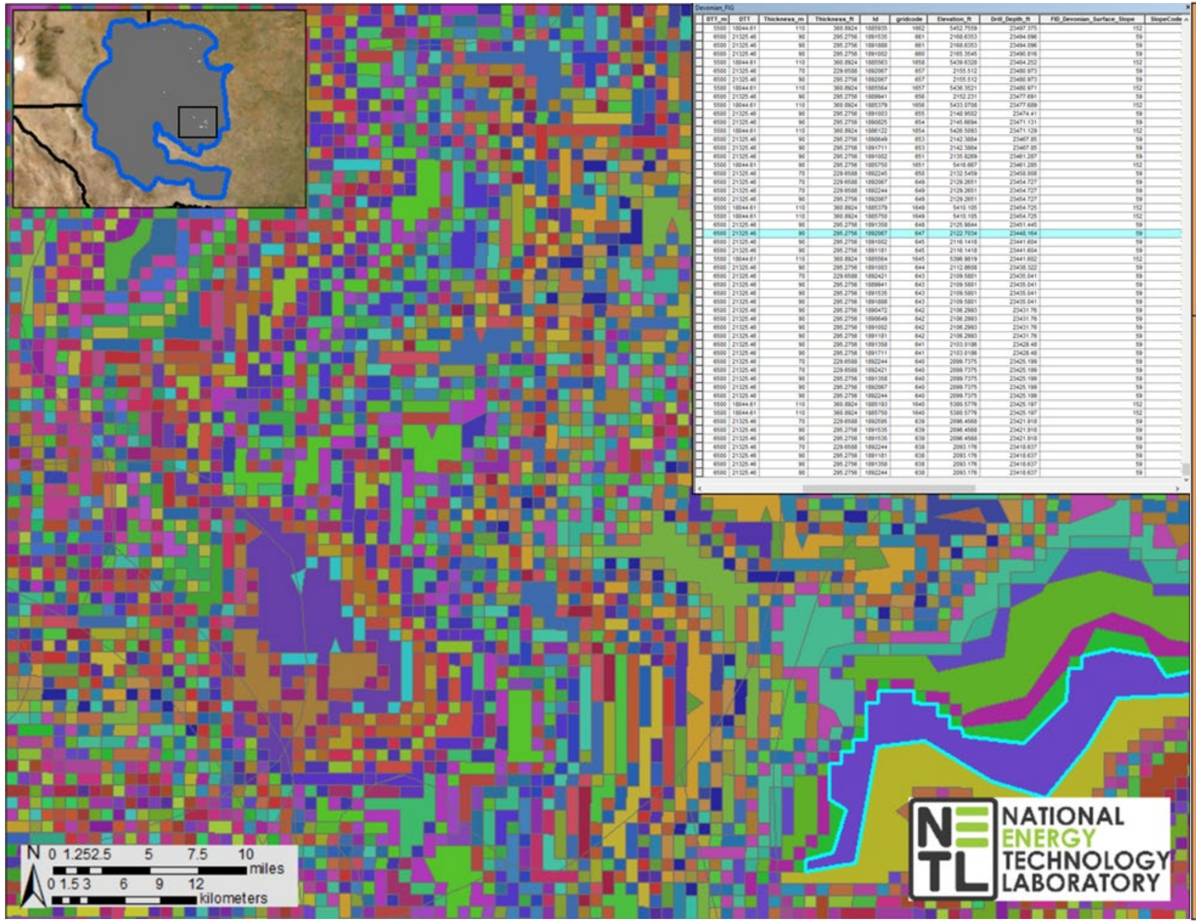
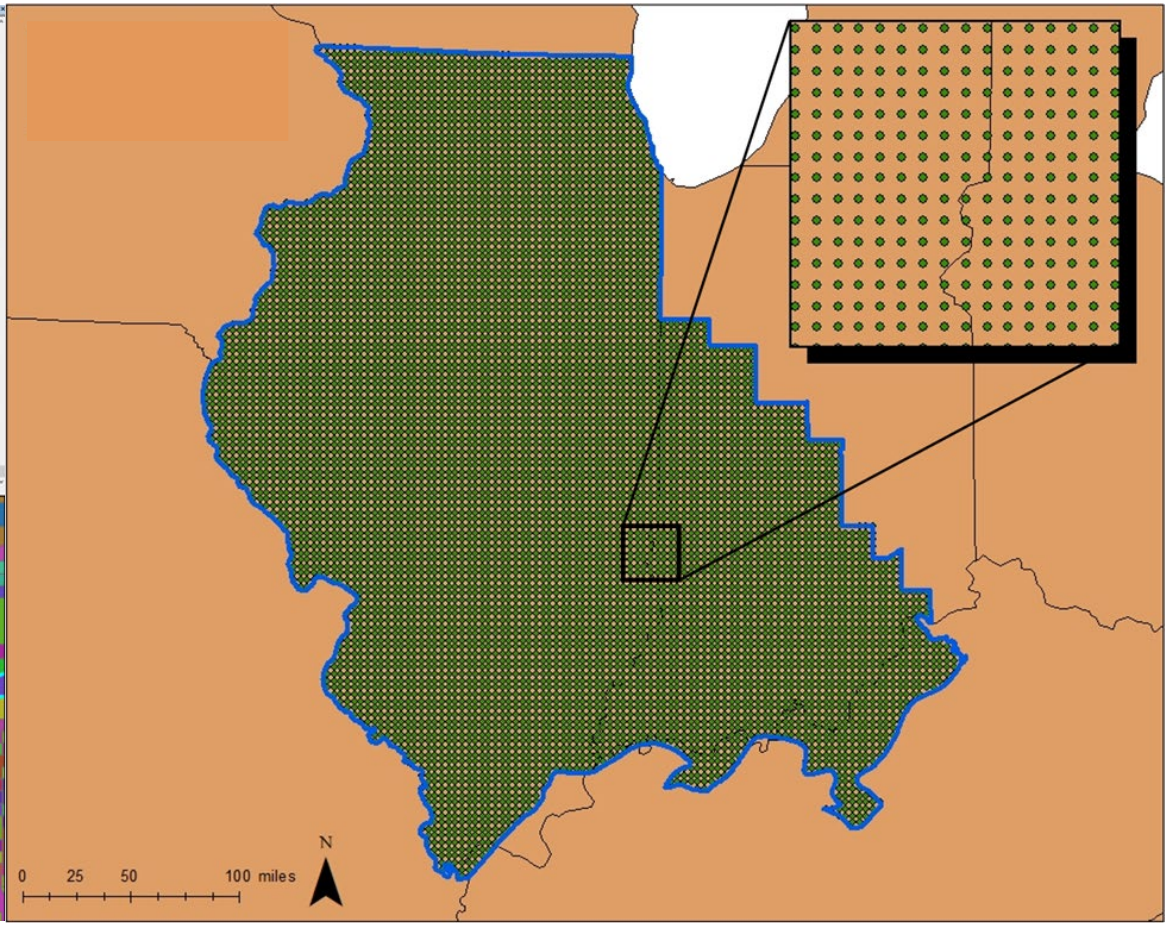
The parameters are summarized in a Fully Integrated Geodatabase (FIG):

- A GIS file that often consists of tens of thousands of individual polygons with discrete attributes.
- The FIG is sampled with a 5 km grid, resulting in an independent spatial quantification for the potential of GCS.





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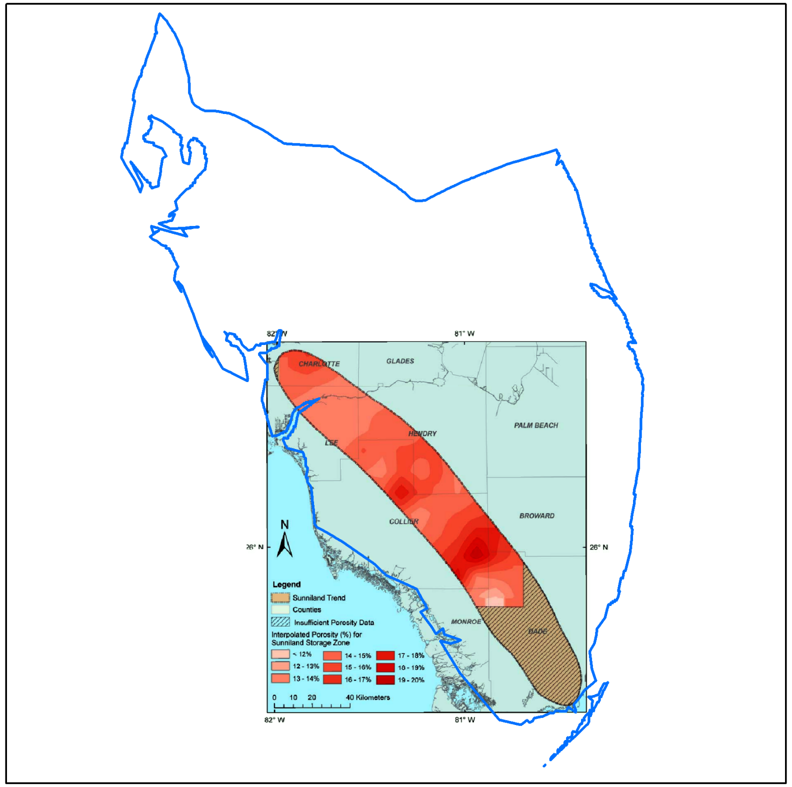
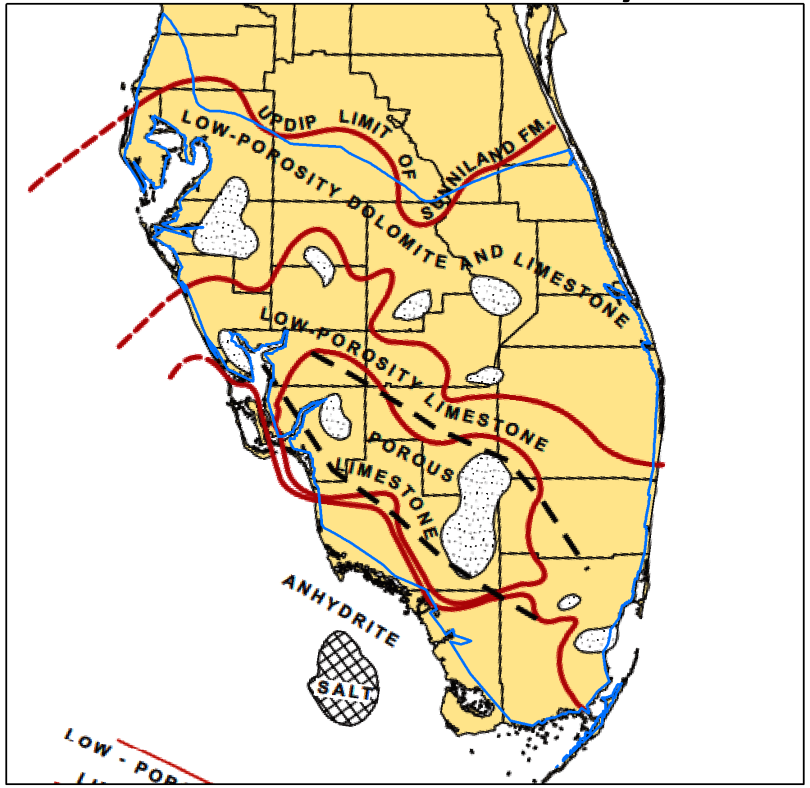
- Methods to characterize formations include:
  - Georeferencing published maps (i.e., structural contours, isopach maps, porosity maps)
  - Contouring
- Example: Sunniland formation in Florida

Sunniland Formation – Porosity Map



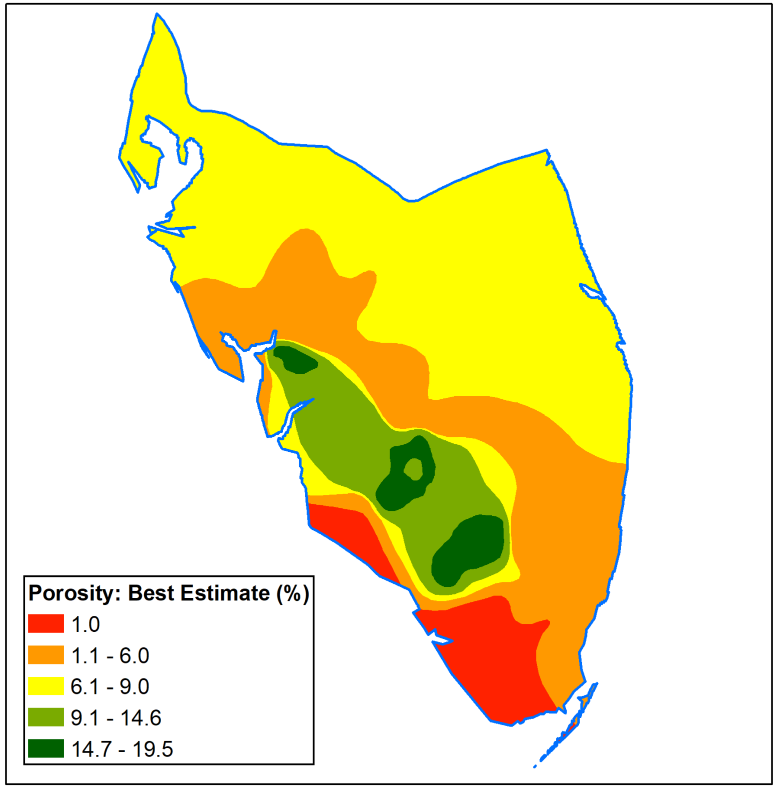
Porosity map from Roberts-Ashby, 2010, Figure 2-36

Sunniland Formation – Porosity Trends



Porosity delineation from Pollastro et al., 2001, Figure 9

Final Porosity Result for Sunniland Formation



Project Status and Accomplishments – Task 12a

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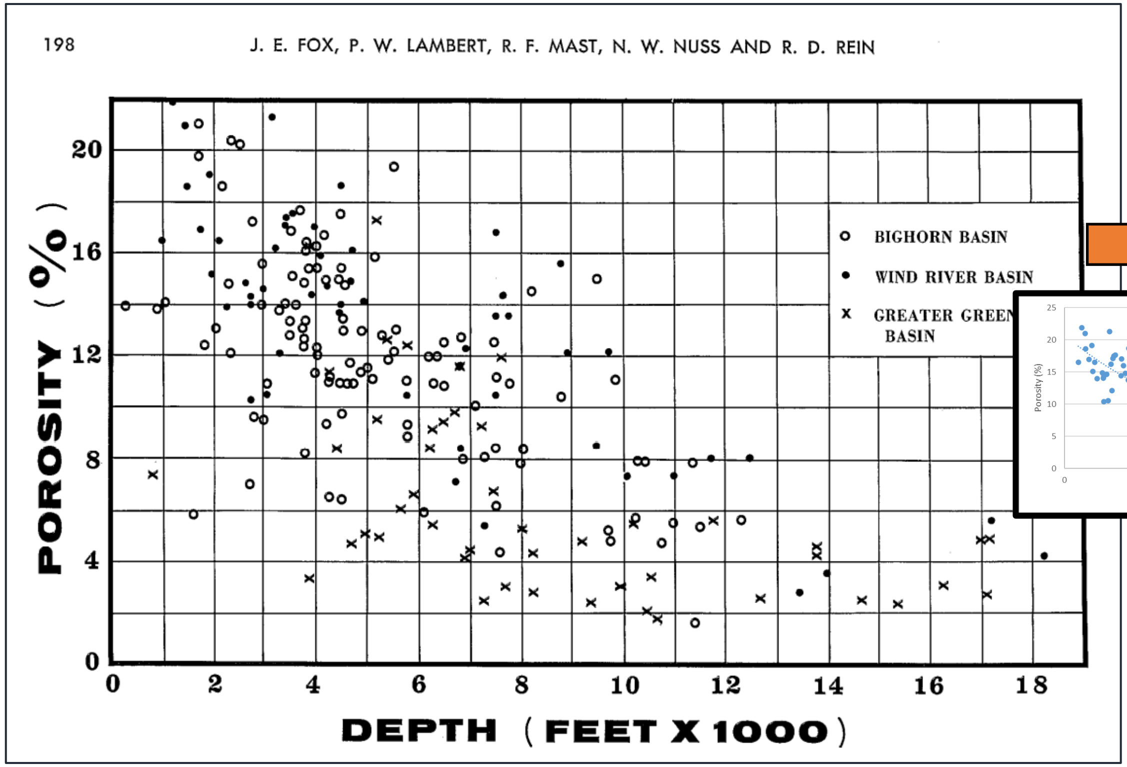
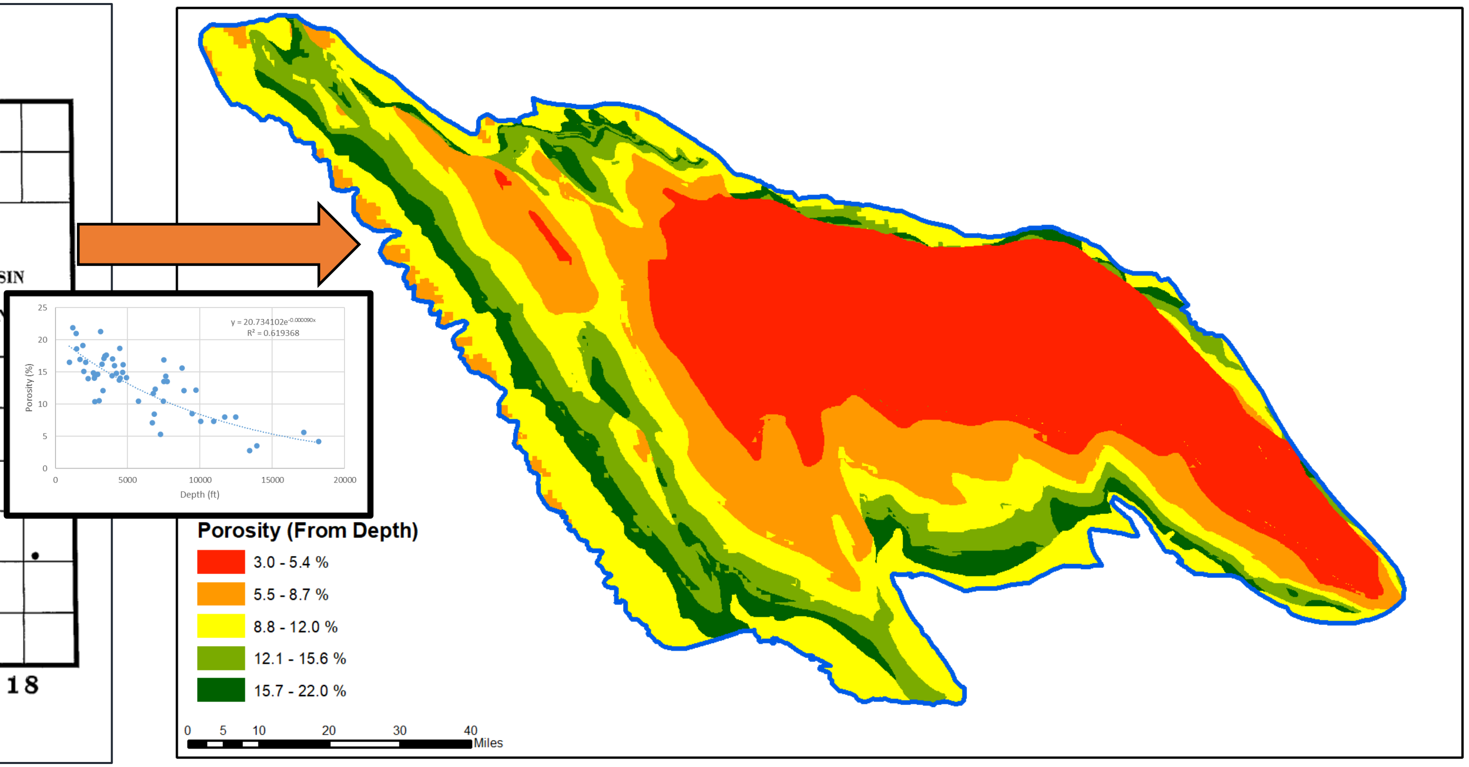
- Methods to characterize formations include:
  - Cross plot regression relationships (i.e., porosity and depth, porosity and permeability)
- Example: Tensleep formation in Wind River Basin

Tensleep Formation – Porosity vs. Depth



Fox et al. 1975, Figure 7

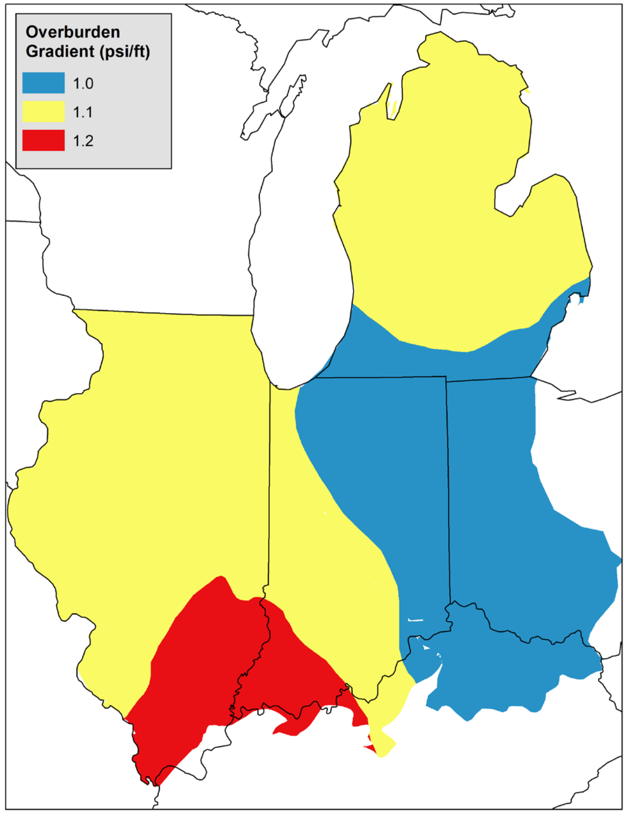
Tensleep FIG – Porosity from Depth



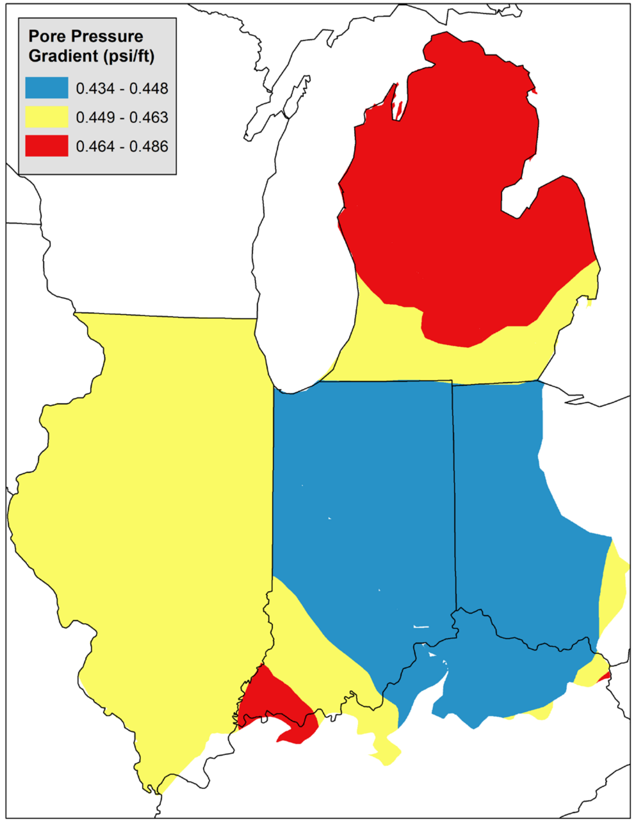
Project Status and Accomplishments – Task 12a

- **Methods to characterize formations include:**
  - Mapping geologic parameters of Poisson's ratio, overburden stress, and pore pressure to analytically estimate fracture pressure
- **Example: Mount Simon formation in Michigan, Illinois, and Inner-Arch Basins**

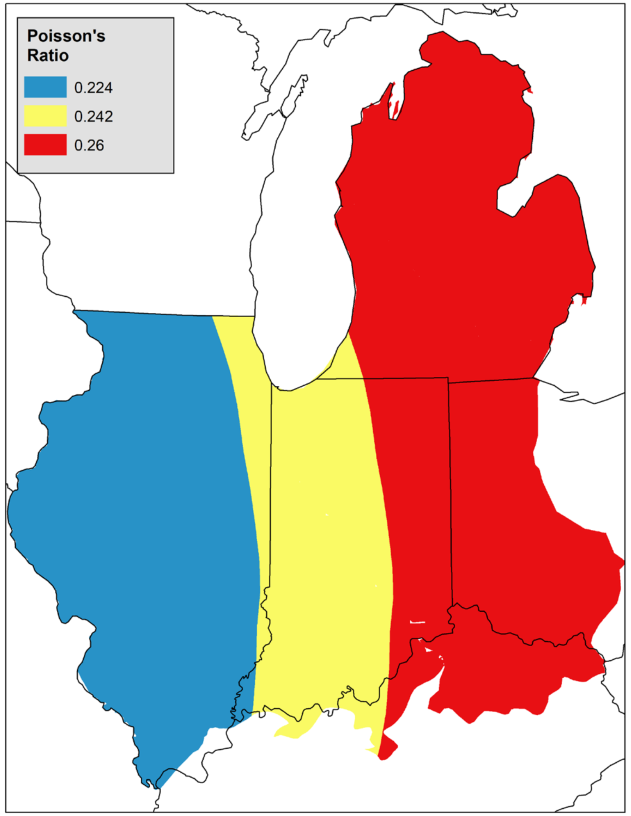
Overburden Gradient



Pore Pressure Gradient



Poisson's Ratio



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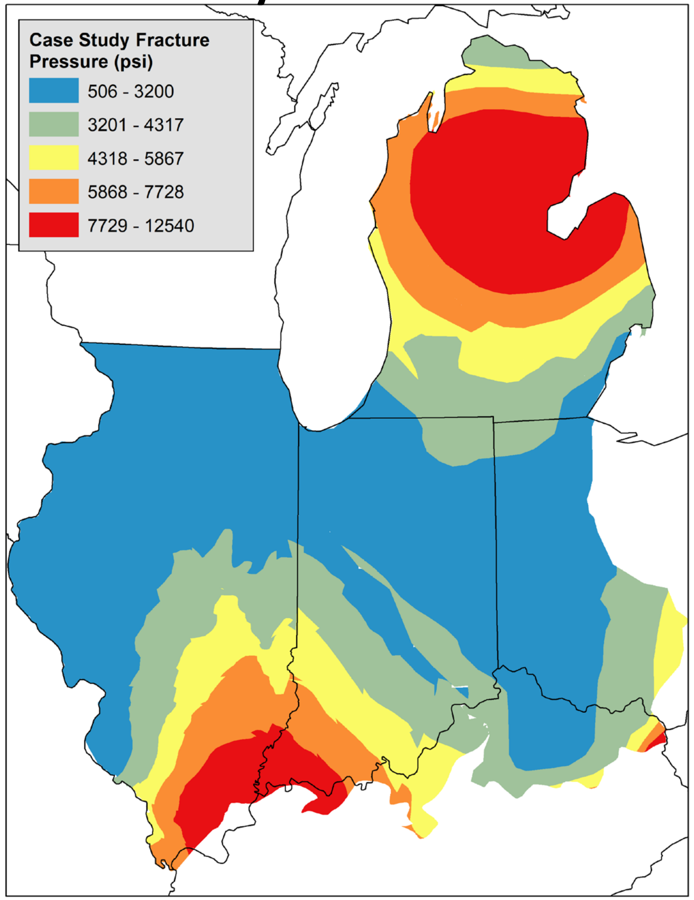
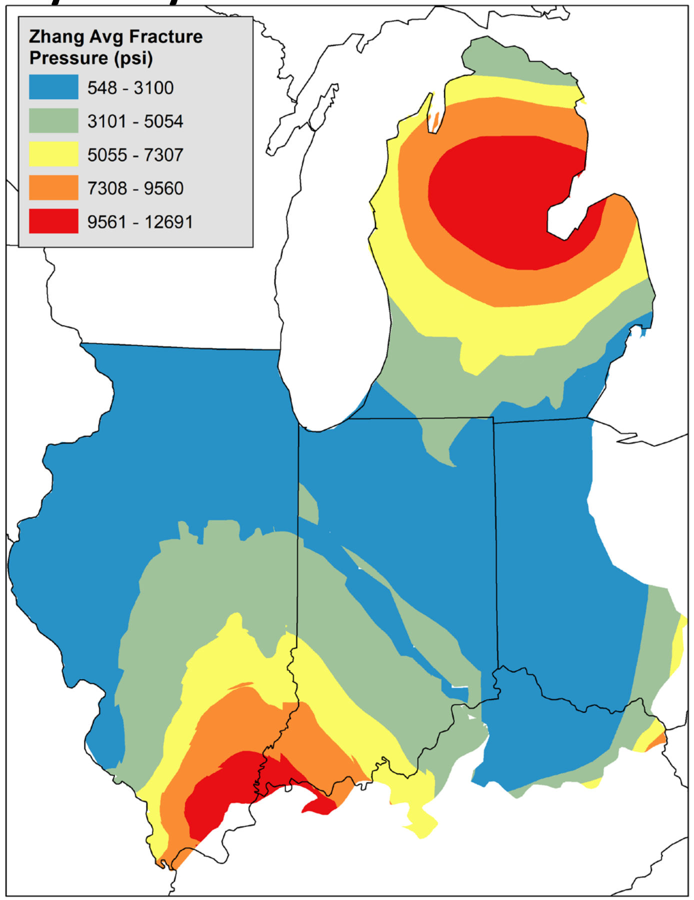
- **Example: Mount Simon formation in Michigan, Illinois, and Inner-Arch Basins (continued)**
  - The average percent difference is 1.5% (based on 5 km grid space averaging)

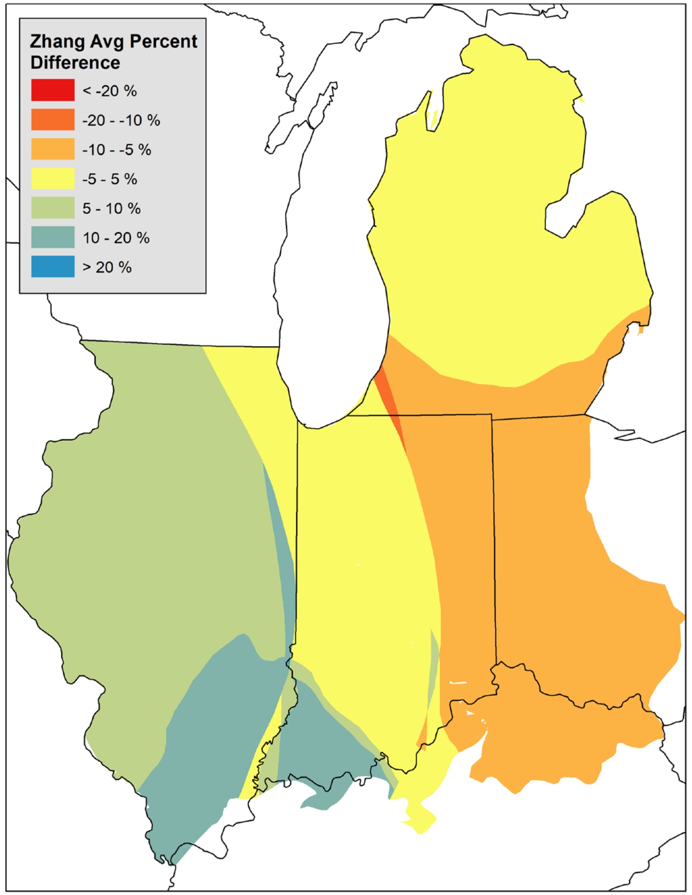
Case Study Fracture Pressure



Analytically Derived Fracture Pressure



Percent Difference Is Minimal



Project Status and Accomplishments – Task 12a

- **Methods to characterize formations include (by way of example):**
  - Developing a methodology to estimate inclination of the formation based on structural depth
  - Manual identification and delineation of major anticlinal and domal structures from structural depth
  - Converting hydraulic conductivity maps and values to permeability

- **57 geologic formations were updated through Phase 4, with 18 geologic formations updated (as of August 24) with fracture pressure estimates through Phase 5**

Project Status and Accomplishments – Task 12b

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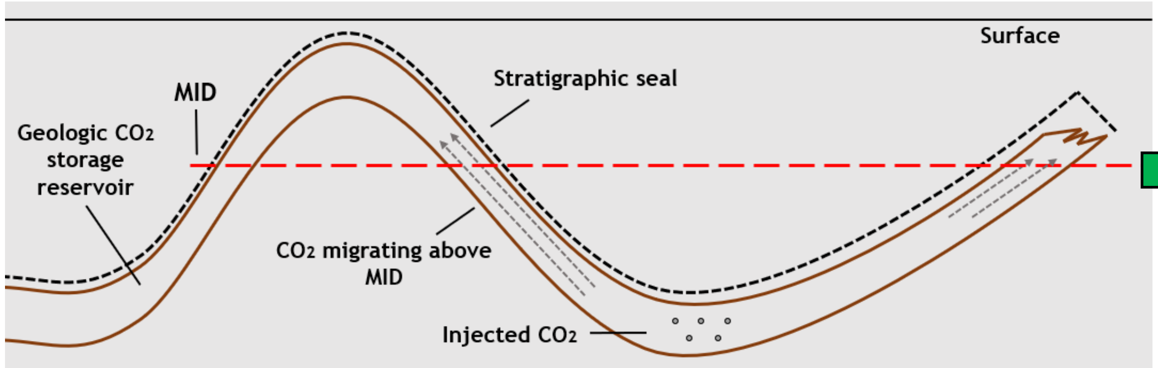
- **Task 12b provides CO2_S_COM with an independent check using GEESS data**
  - Individual geologic parameters (i.e., porosity and permeability) will be compared between the two datasets
  - Using a standardized set of non-geologic inputs (e.g., financial, engineering), outputs of the CO2_S_COM model will be compared between using GEESS and CO2_S_COM data.
    - Tables and difference maps will be created to highlight the magnitudes of differences between GEESS and CO2_S_COM and improve input datasets for CO2_S_COM

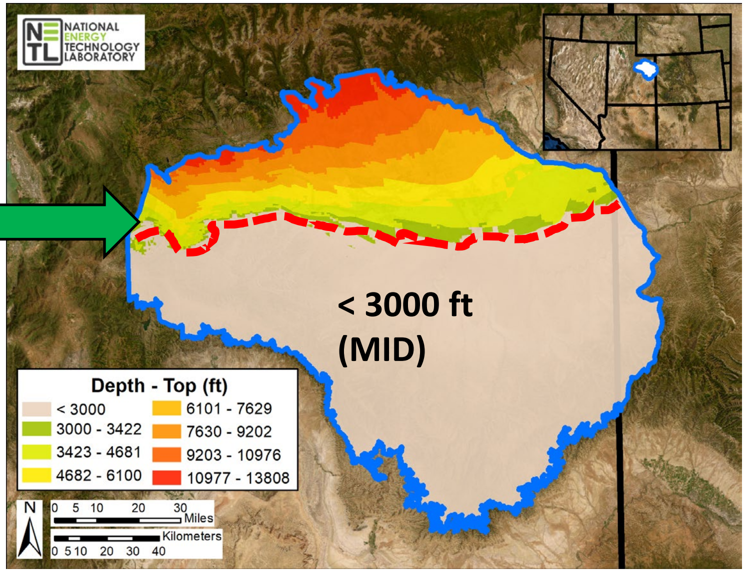
- **GEESS provides flexibility to change grid spacing to depict independent project locations in CO2_S_COM**

Project Status and Accomplishments – Challenges

Challenge	Mitigation Strategy
There can be variability in quality and quantity of available data for geologic formations across the U.S.	Addressed by algorithms and analogs
Data can be concentrated in legacy oil and gas assets, which typically contain the best reservoir quality of a formation (i.e., net porosity vs. gross porosity)	Addressed by rigorous assessment of literature and evaluation of geospatial nature of data
CO2 injected into a saline formation may travel up-dip, crossing into volumes of the formation that are shallower than 3,000 ft (the Minimum Injection Depth, MID) or in areas with less than 10,000 mg/L salinity. Aquifers and other formations need to be protected during injection	Possible consideration in future GEESS Phases



Green River Formation, Uinta Basin



Next Steps

- 32% of formations updated with fracture pressure (through Aug. 24, 2023)
- Projected Schedule:

TASK	PROGRESS	START	END	May, 2023	June, 2023	July, 2023	Aug., 2023	Sept., 2023	Oct., 2023	Nov., 2023	Dec., 2023	Jan., 2024	Feb., 2024	March, 2024
Task 12a - Fracture Pressure Database														
Establish Fracture Pressure Methodology	100%	5/1/23	6/30/23											
Incorporate Fracture Pressure Estimates into FIGs	21%	6/1/23	1/31/24											
Milestone: List of References	0%	9/15/23	10/27/23											
Milestone: Fracture Pressure Database	0%	2/1/24	2/29/24											
Task 12b - CO2_S_COM Comparison														
Establish Task 2 Methodology	25%	7/1/23	8/31/23											
Determine CO2_S_COM Base Case	0%	8/1/23	10/31/23											
Deteremine GEESS-CO2_S_COM Scenario	0%	10/1/23	1/31/24											
Develop Optimum Grid Size to Determine Project Independence	0%	1/1/24	2/29/24											
Milestone: Comparison of CO2_S_COM & GEESS; Reporting	0%	3/1/24	3/31/24											

- Additional potential parameters to include in GEESS: high storage efficient GCS sites, heat maps, $/ton of CO_2 injected, injection rate, volume of CO_2 storage
- Posting GEESS to NETL's Energy Data eXchange (EDX)

Lessons Learned To Date

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- **The quality and quantity of public domain data varies among GEESS formations**
  - We need to be aware of biases in public-domain literature that can occur due to the prevalence of reservoir-quality data as opposed to gross data (i.e., net porosity vs. gross porosity)
- **Geologic formations are heterogenous and complex**
- **There is material variability in the ability to store carbon among the various formations, as well as within the formations themselves**
- **GEESS can be a mechanism to facilitate the commercialization of geologic carbon sequestration in that it provides a standardized, detailed platform**
  - Is compatible with CO2_S_COM
  - Can provide an assessment of R&D impacts
  - Can be used as a meaningful screening tool for project suitability

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Questions/ Comments

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