Integrated Midcontinent Stacked Carbon Storage Hub

DE-FE0031623

Andrew Duguid
Battelle
505 King Ave
Columbus, Ohio 43201
Duguid@battelle.org
+1 614 561 4468

U.S. Department of Energy
National Energy Technology Laboratory
Addressing the Nation’s Energy Needs Through Technology Innovation – 2019 Carbon Capture, Utilization, Storage, and Oil and Gas Technologies Integrated Review Meeting
August 26-30, 2019

BATTELLE

Project Team

ADM

ARI

Battelle

Berexco

Conservation and Survey Div, SNR, UNL

DGR&M

Energy and Environment Research Center

Great Plains Energy

Great Plains Institute

Improved Hydrocarbon Recovery

Kansas Geologic Survey

LANL

Loudon Technical Services

Nebraska Public Power District

PNNL

Schlumberger

Introduction

- The Integrated Midcontinent Stacked Carbon Storage Hub plans to gather CO_2 from eastern and central NE and transport it southwest toward Red Willow County, NE along a CO_2-source collection corridor. The CO_2 will then be piped south into central KS along a stacked storage corridor.
- CarbonSAFE Program Objective: Develop a midwestern carbon storage facility having multiple sites with a 50-Mt or greater capacity to safely, permanently, and economically store CO_2 by 2025.

BATTELLE

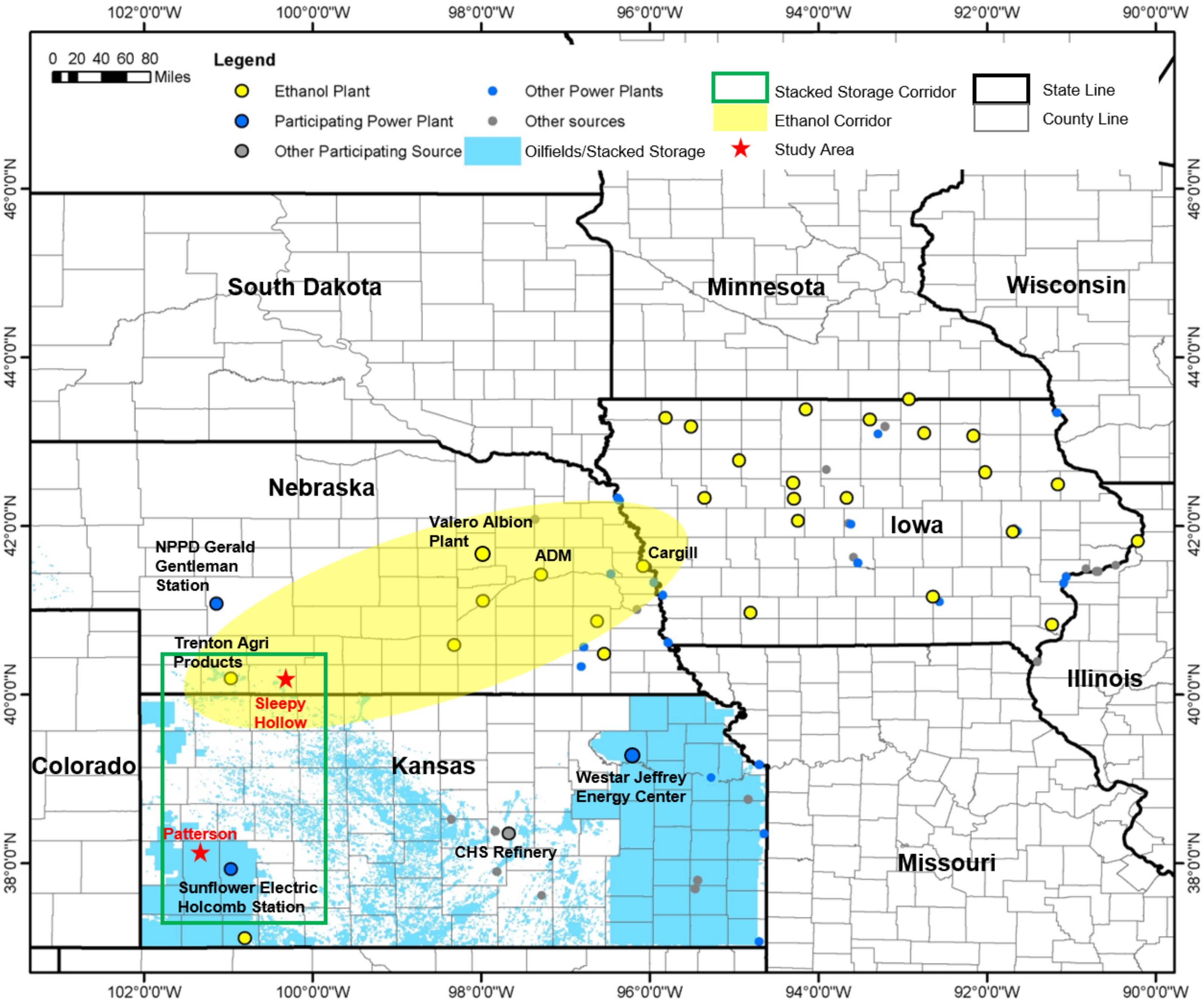
Phase II IMSCS-HUB Objectives

- Objective 1: Demonstrate multiple 50 Mt storage sites for the IMSCS-HUB concept by evaluating a Kansas and Nebraska site, each with the ability to safely, permanently, and economically store anthropogenic CO_2 through stacked-storage.
- Objective 2: Develop 50 Mt+ storage scenarios and provide a basis for UIC permitting.
- Objective 3: Demonstrate long-term seal integrity and minimize induced seismicity.
- Objective 4: Develop strategies to manage and store CO_2 from multiple sources.
- Objective 5: Leverage the data collected to scale the project to develop a regional commercial enterprise (three to ten 50 Mt+ storage sites).
- Objective 6: Identify and mitigate public outreach and regulatory barriers
- Objective 7: Develop a detailed commercial development plan.

BATTELLE

Project Area

- Kansas
- Nebraska
- Kansas



BATTELLE

Corridors

- Source Corridor (Initially Ethanol Derived CO_2)
  - Run across IA into NE and then southwest across NE
  - Optimize maximize the number of sources/amount of CO_2 to develop market and infrastructure for CCUS
    - Ethanol plants in the corridor with annual emissions of greater than 5 Mt. Capture in the $12/t range
    - Saline storage at many of the ethanol plants in NE
    - Bring in electric utility generated CO_2 as capture comes on line. Existing market from ethanol derived CO_2 will provide certainty that a utilization market and storage is possible
    - 5 other sources (4 electric utility and 1 refinery) with 20 Mt annual emissions. Capture in the $57/t range (NETL 2015)
- Stacked Storage Corridor
  - Run from SW NE southeast into SW KS
    - Saline storage and CO_2 EOR
    - Co-locate infrastructure for Saline and CO_2 EOR.

BATTELLE

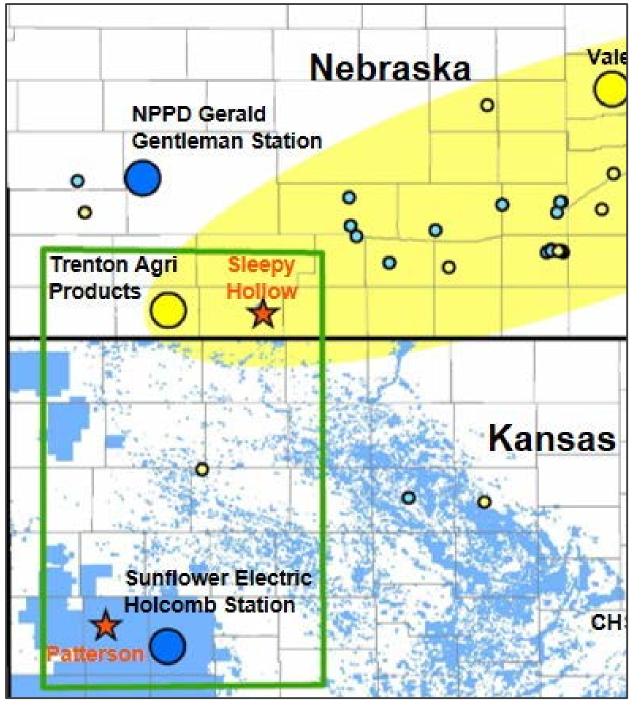
Storage: Geology

STRATIGRAPHY*					
Era	**Period**	**Southwest Nebraska**		**Southwest Kansas**	
Paleozoic	Permian	Nippewalla	caprock	Nippewalla	caprock
		Sumner		Sumner	
		Chase	baffle	Chase	gas-bearing
	Pennsylvanian	Council Grove	caprock	Council Grove	
		Admire		Admire	baffle and deep saline
		Wabaunsee	deep saline	Wabaunsee	
		Shawnee		Shawnee	
		Douglas		Douglas	
		Lansing-Kansas City	oil-bearing	Lansing-Kansas City	oil-bearing
		Pleasanton	deep saline	Pleasanton	baffle and deep saline
		Marmaton		Marmaton	
		Cherokee		Cherokee	caprock
		basal sandstone	oil-bearing	Atoka	
				Morrow	oil-bearing
	Missippian			Chester	oil-bearing
				Meramec	baffle
				Osage	deep saline
				Kinderhook	baffle
	Devonian				
	Silurian				
	Ordovic-ian			Viola	deep saline
				Simpson	
	Cambrian			Arbuckle	
				Reagan	bottom barrier
Precambrian		crystalline basement			

* *formal lithostratigraphic group and stage names used unless otherwise noted; not to scale*

LEGEND:

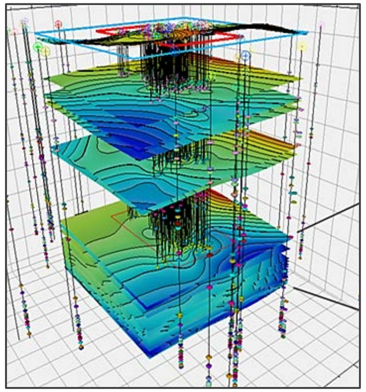
- *shale + limestone*
- *shale + sandstone + limestone*
- *shale + limestone ± evaporite*
- *shale + sandstone*
- *limestone ± shale*
- *sandstone + limestone ± shale*
- *sandstone*
- *dolomite*
- *igneous and metamorphic rocks*
- *major unconformity*



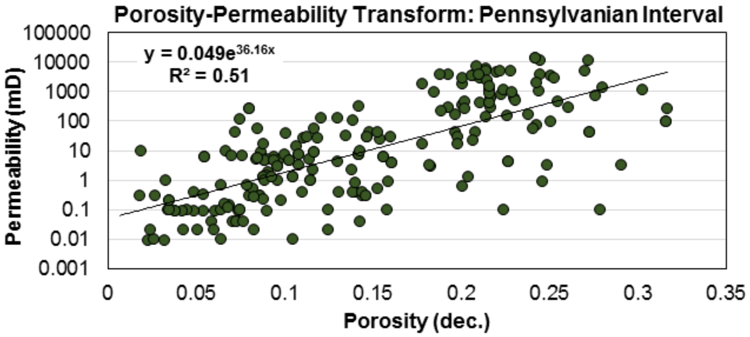
BATTELLE

Geologic Characterization Workflow

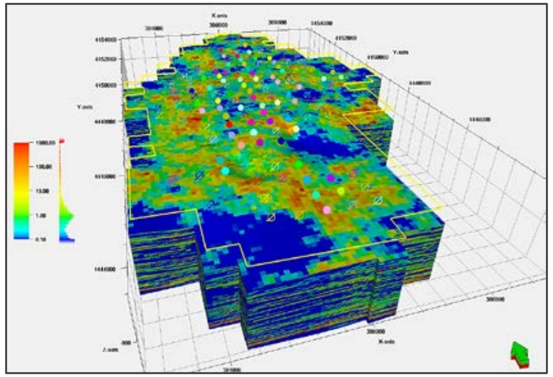
Structural and Stratigraphic Framework



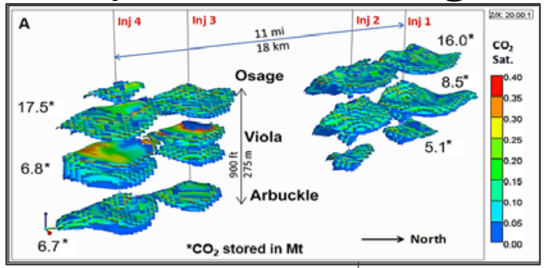
Petrophysical Analysis

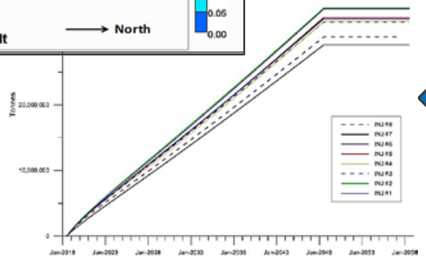


Static Earth Modeling



Dynamic Modeling

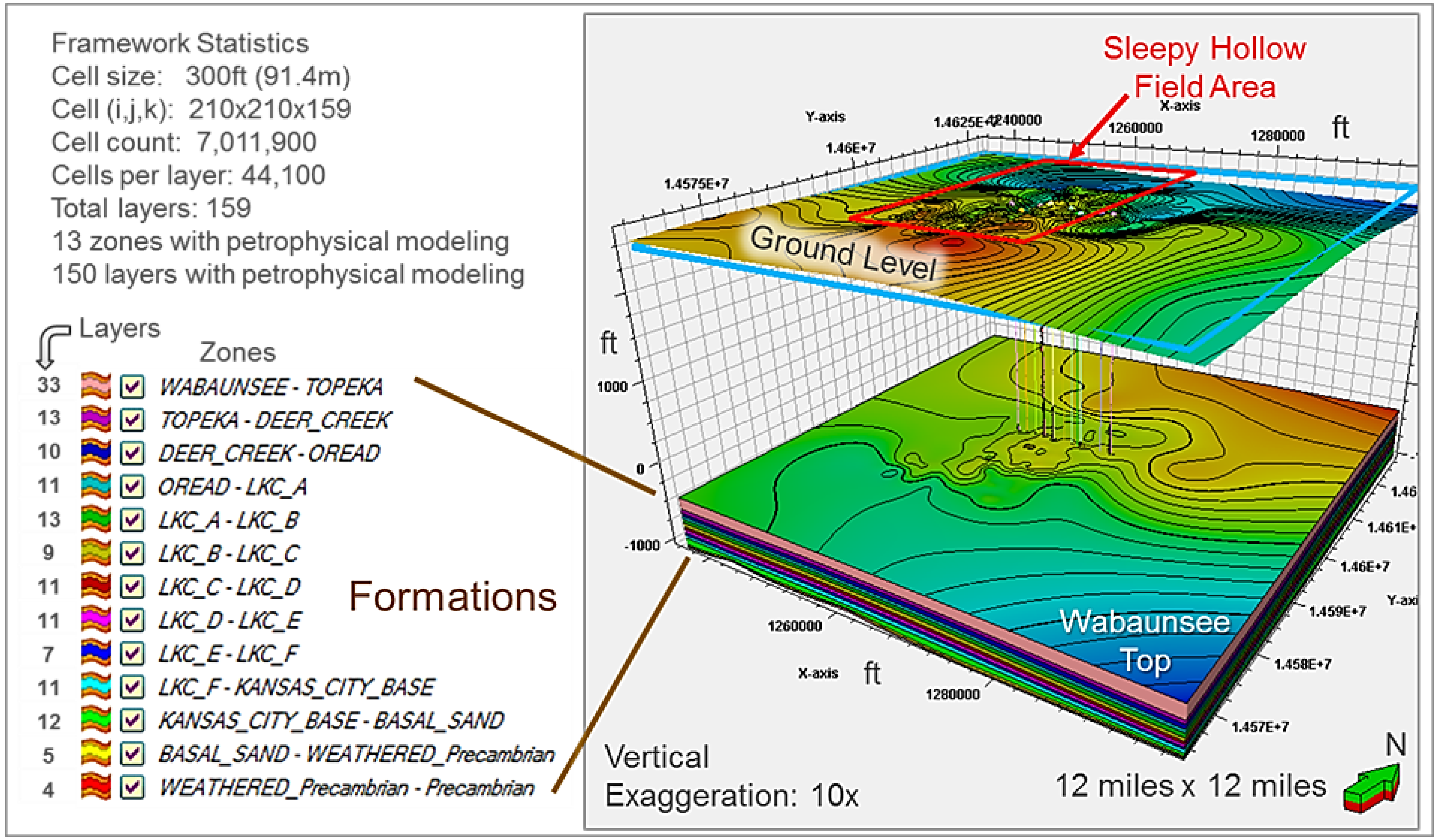




BATTELLE

Petrophysics and Static Earth Model

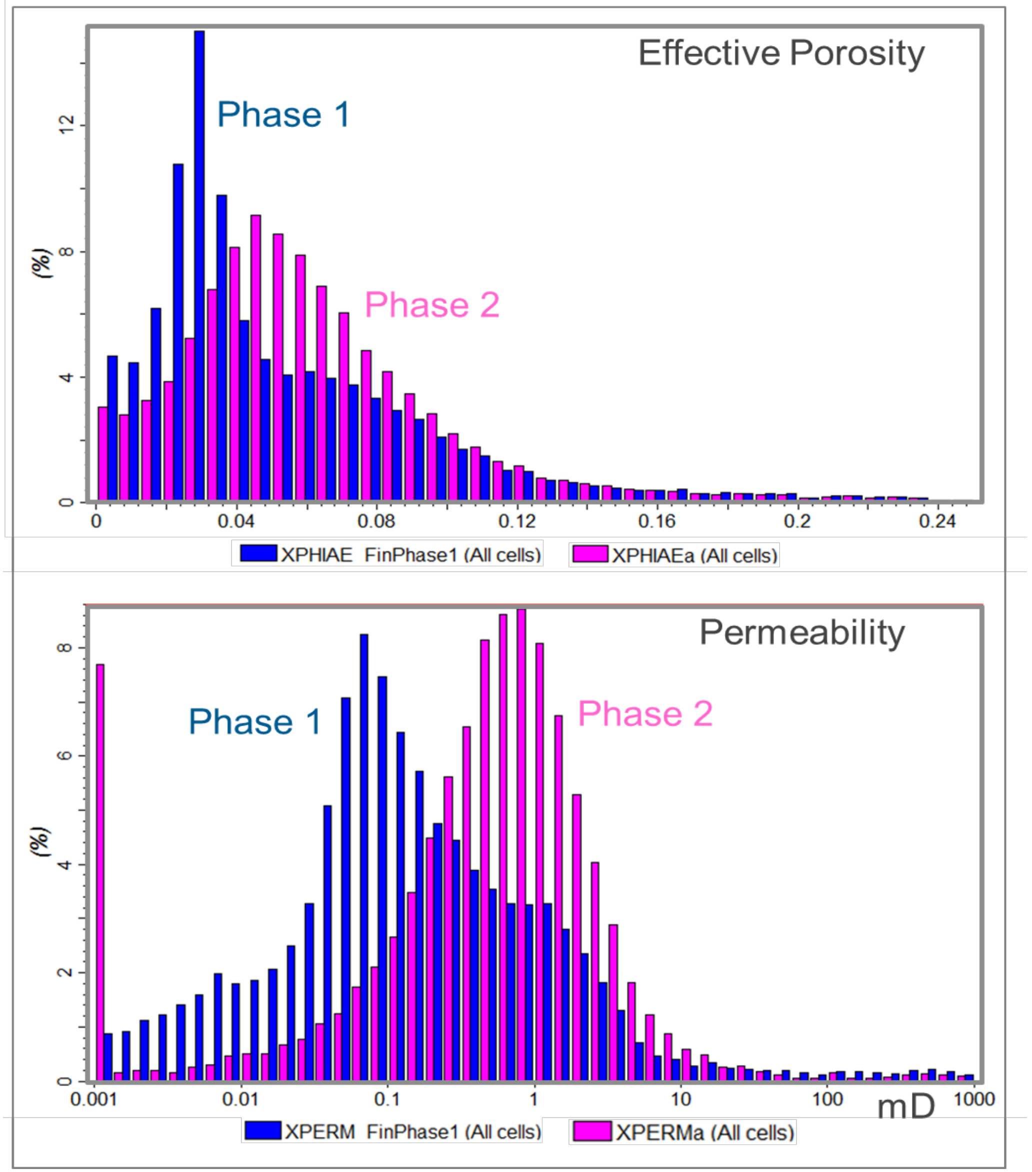
- Structural and stratigraphic framework from formation tops in 205 wells
- Log data from 171 wells (e.g. gamma ray, neutron, density, sonic)
- 267 core data measurements (e.g. porosity, perm, grain density) from 13 wells



Static Earth Model Updates

Effective porosity and permeability histograms for Phase I and Phase II SEMs for the Sleepy Hollow site

Differences due to addition of new core data and updated porosity-permeability transforms



Data Gap Assessment

Data Gaps were examined to address:

1. Regulatory requirements
   - EPA UIC Class VI requirements
     - Fluid Sampling and Coring
     - Well Logging and Testing
2. Reduction in uncertainty of the geologic and reservoir models

Data gaps identified are related to:

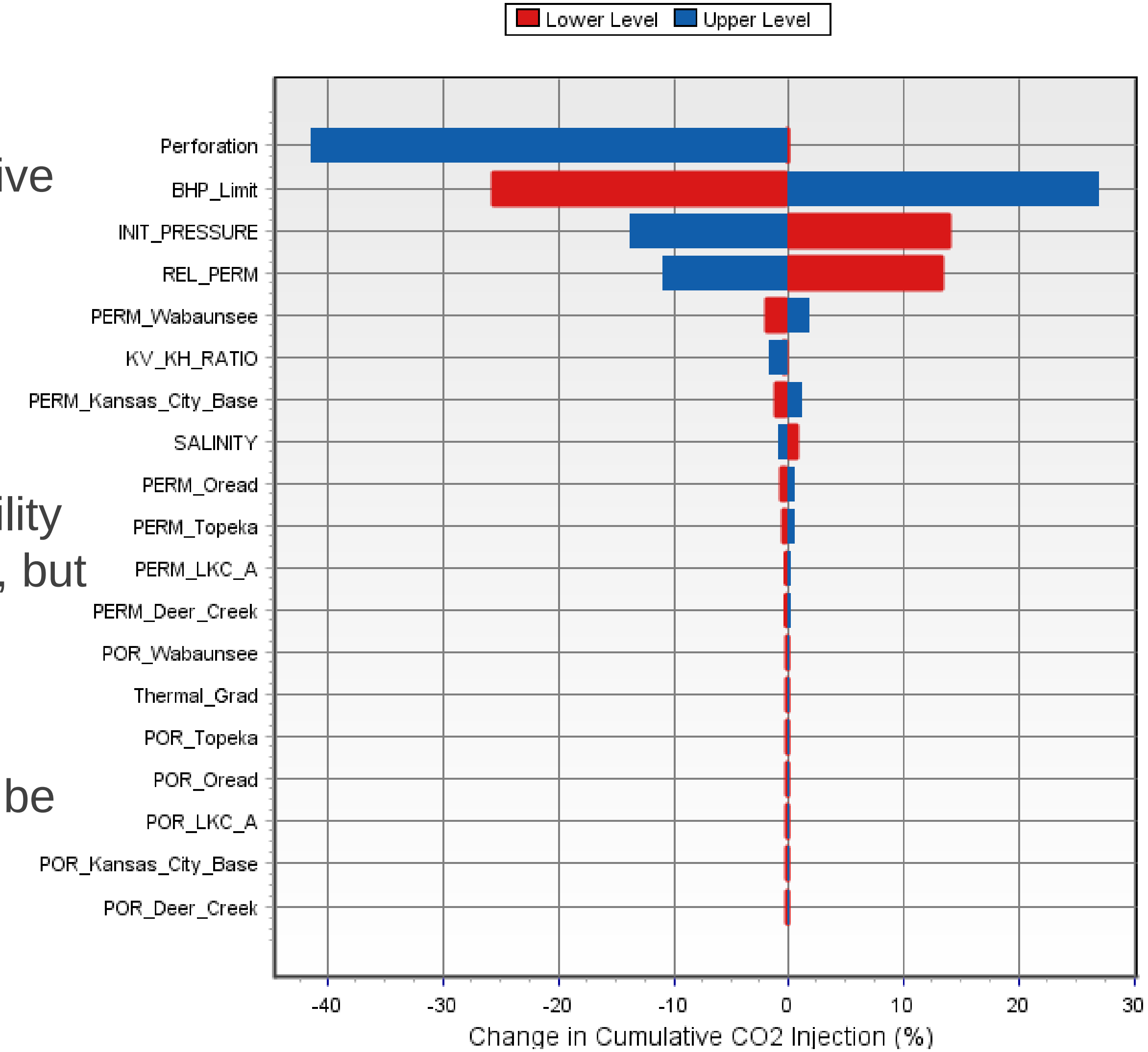
- Lithologic data
- Geophysical/Model data
- Geomechanical data
- Geochemical data

Sensitivity Analysis

CO_2 storage is most sensitive to perforation zone, BHP constraints, initial reservoir pressure, and CO_2-brine relative permeability

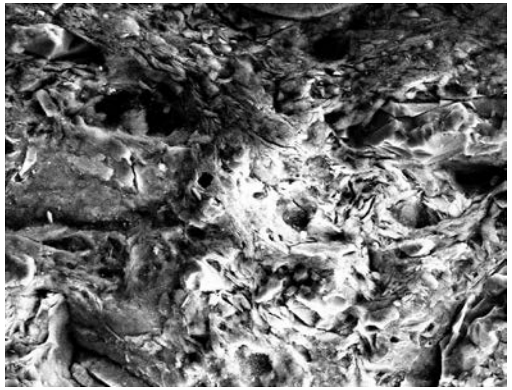
Effects of vertical permeability anisotropy is less sensitive, but non-negligible.

Sensitivity to salinity and thermal gradient appear to be insignificant.



New Geologic Data Collection Plan

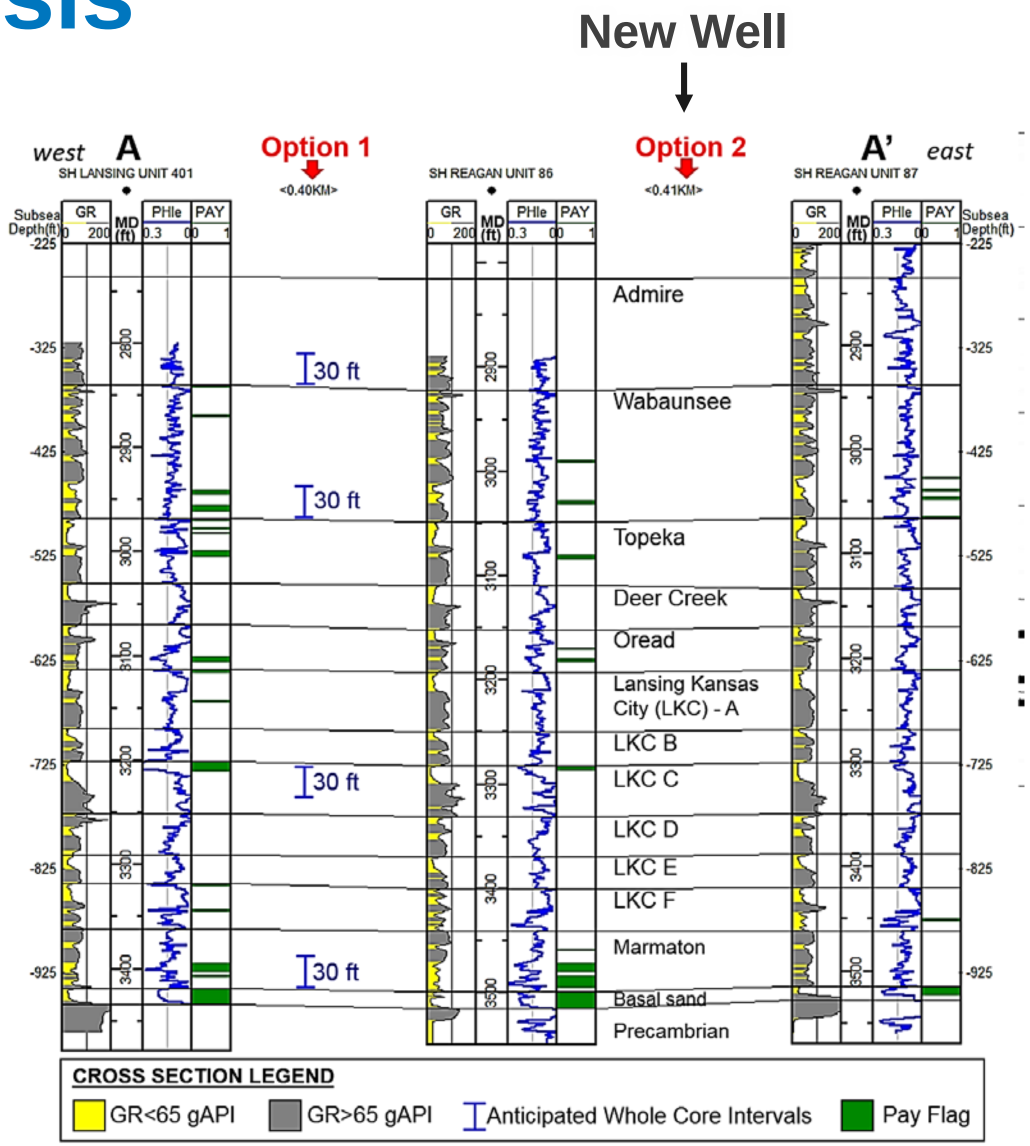
- **Drilling one new characterization well**: Sleepy Hollow field SW Nebraska
- **New whole core** for specialized core analysis (e.g. rel. perm, geomechanics)
- **Advanced wireline log data:** e.g. elemental spectroscopy, nuclear magnetic resonance, micro-imagers.
- **Well tests** – DSTs, mini-frac, to evaluate injectivity, permeability, pressure response.



BATTELLE

Whole Core and Analysis

Analysis	Core Samples
Thin-Section Slide Preparation	reservoir & caprock
Thin-Section Petrography	reservoir & caprock
Bulk Mineralogy	reservoir & caprock
Plug Drilling	reservoir & caprock
Water and Oil Fluid Saturations (reducible)	reservoir
Routine Core Analysis	reservoir
Relative Permeability	reservoir
Capillary Pressure	reservoir & caprock
Effective Porosity	reservoir
Fluid Typing and Saturations (irreducible)	reservoir
Tight Rock Micro-porosity, Micro-permeability	caprock
Threshold Entry Pressure	caprock
Rock Mechanics	reservoir & caprock
PVT Fluid Analysis	reservoir

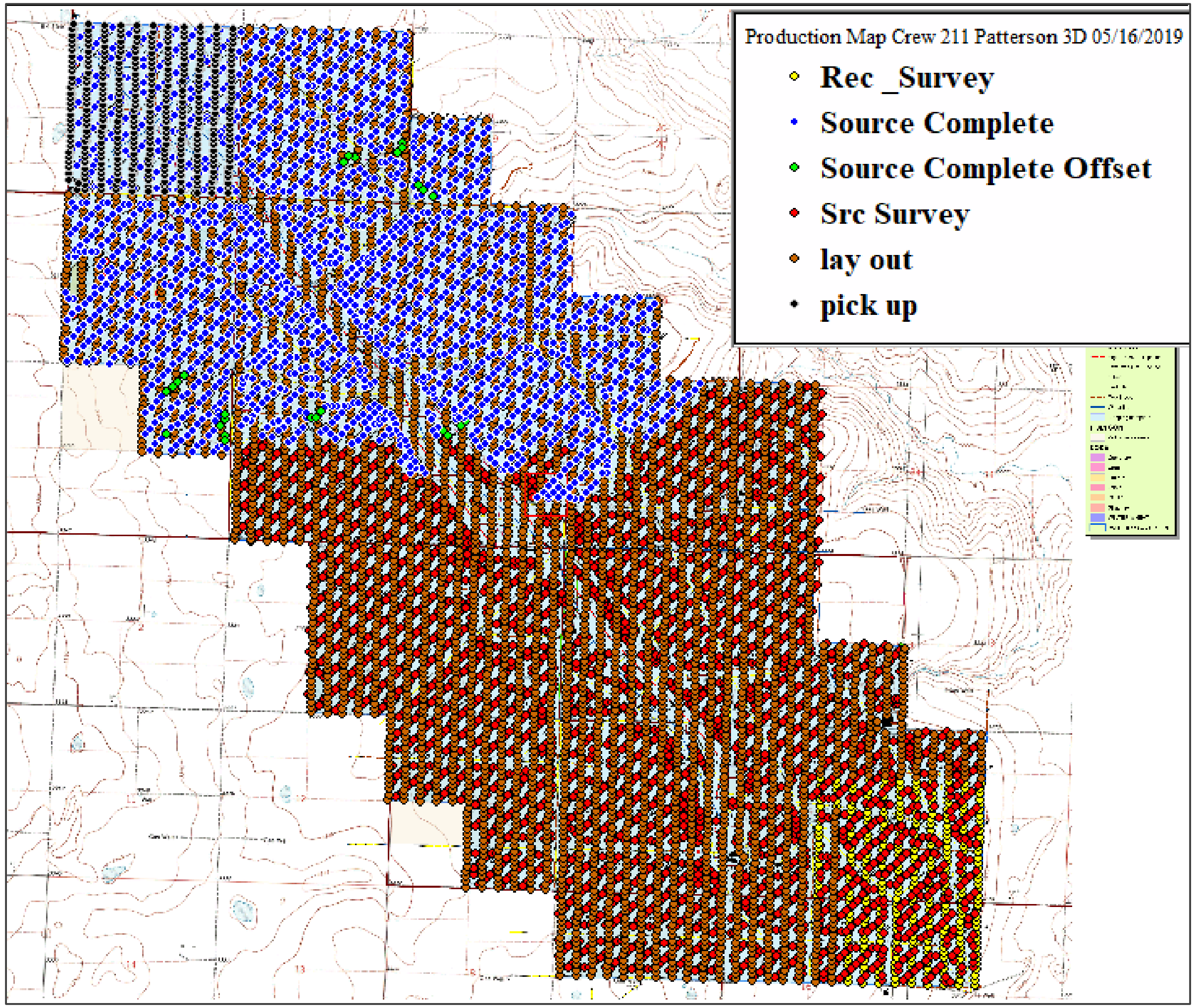


BATTELLE

New Data Collection at Sleepy Hollow Field

- Focus on deep saline intervals in the Pennsylvanian Wabaunsee, Shawnee-Douglas, and Pleasanton-Maramaton groups and caprocks of the Council Grove and Sumner groups
- **Whole Core: 110 ft**
  - **Admire, Wabaunsee, Oread, Marmaton**
- **Sidewall cores: 28**
- **Logs:**
  - **Triple Combo**
  - **Nuclear Magnetic Resonance**
  - **Dipole Sonic**
  - **Formation Micro Image**
  - **Elemental Capture Spectroscopy**

New Data Collection at Patterson Heinitz Hartland



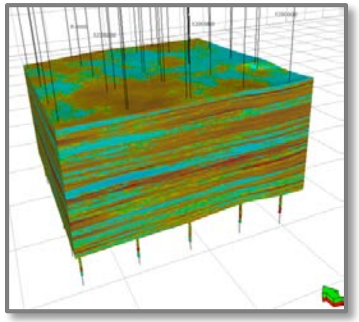
Patterson will focus on Mississippian and Ordovician deep saline storage zones within the Osage, Viola, and Arbuckle formations, and confining units such as the Meramec, Morrow and Sumner Group.

BATTELLE

Next Steps

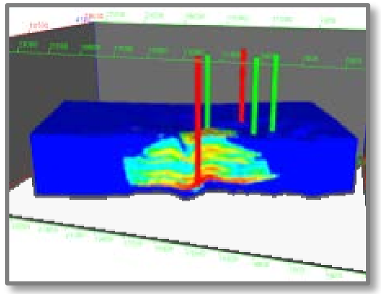
Laboratory core sample measurements

- Petrophysical, lithological, geo-mechanical, fluids
- Validate porosity - permeability relationship



3D Static Earth Model (SEM)

- Refine facies model
- Update 3D petrophysical model
- Update storage resource estimate

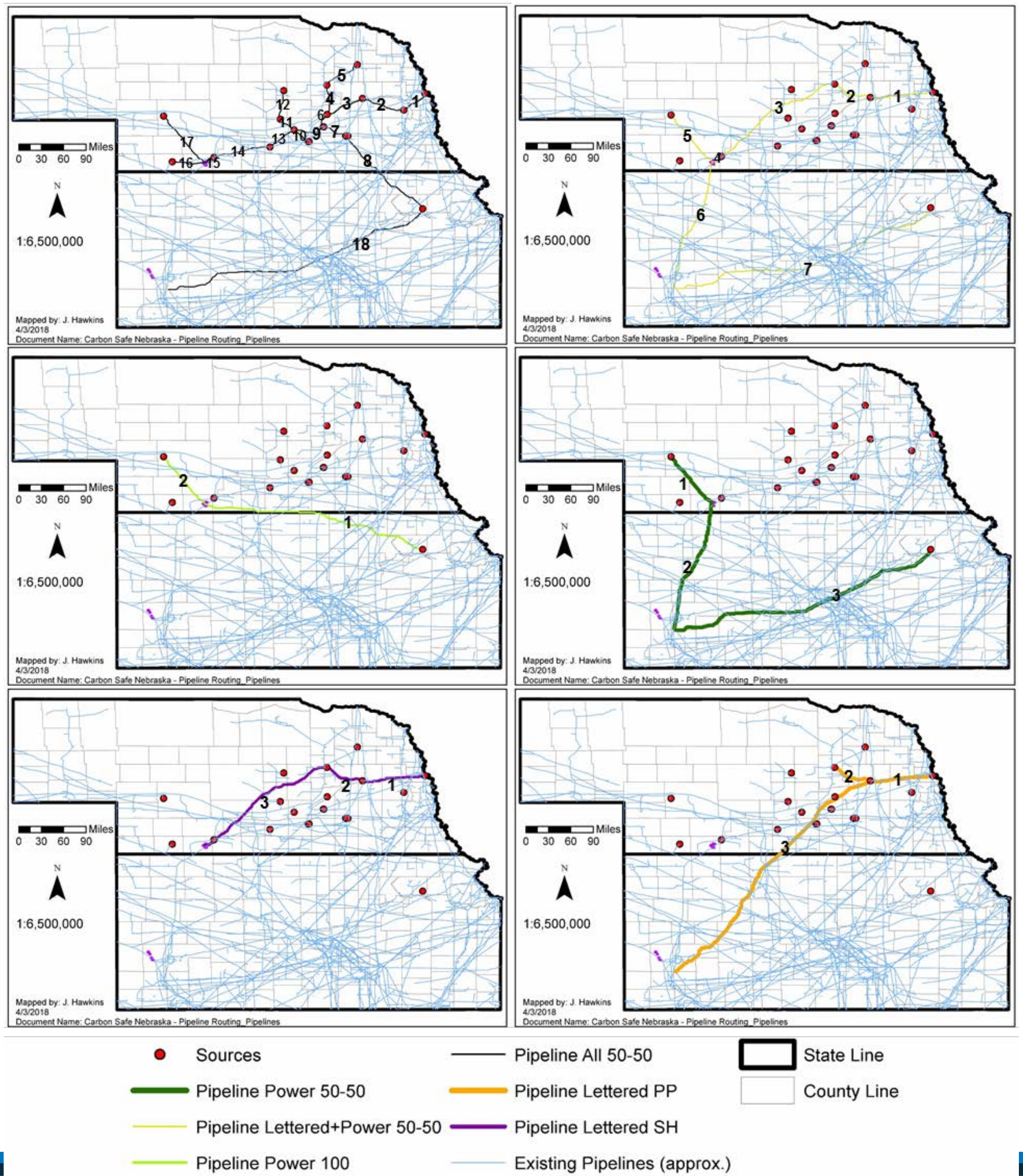


3D Dynamic Reservoir Model (DRM)

- Updated DRM with new capillary pressure, relative perm, and reservoir data
- Update injection strategy and storage resource estimate

Pipeline Routing

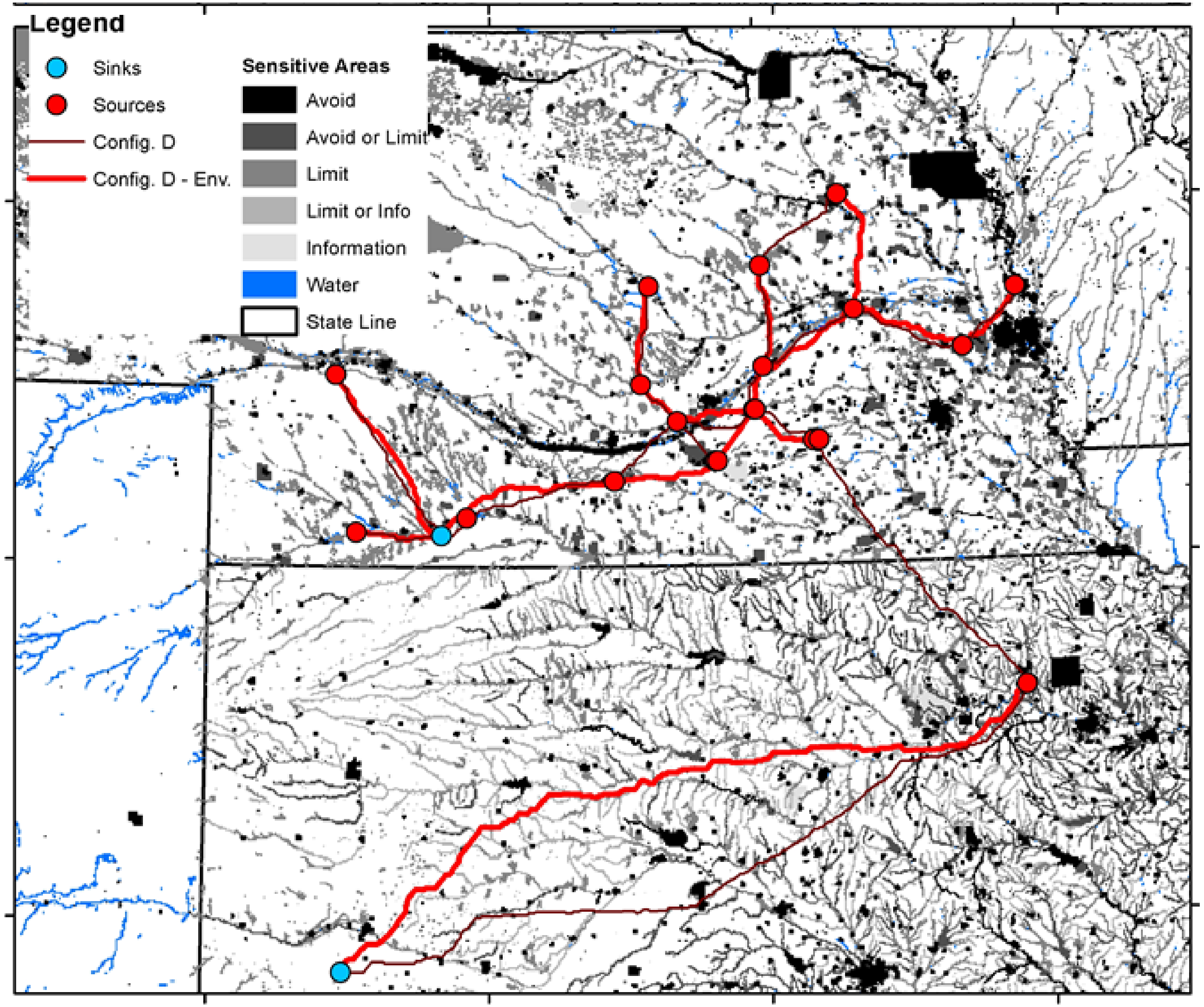
- Ethanol plants in the region use natural gas as a fuel for processing corn.
  - Natural gas pipelines run to every ethanol plant in Nebraska and Kansas.
  - These pipelines occur within 3 miles of each potential site in Nebraska and Kansas.
- Routes generated the weighted-cost surface involves laying a grid overtop of the geographic area and determining the cost to traverse from one cell to a neighboring cell.
- Included Kansas and Nebraska existing pipeline rights of way
- Sources were hardwired into the system



BATTELLE

Geographic barriers

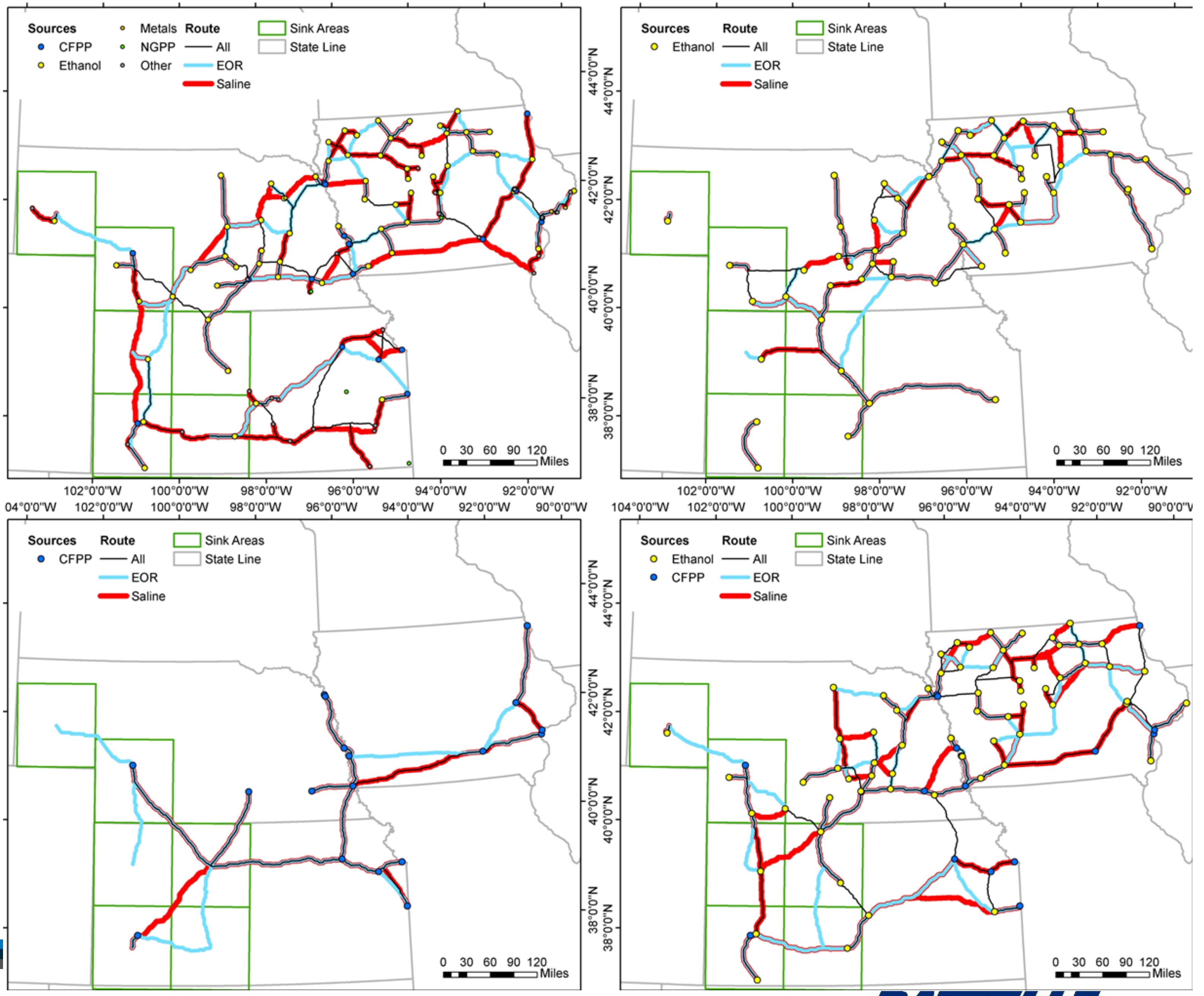
- Air Quality
- Surface Water
- Aquifers
- Wetlands
- Vegetation/Land Cover
- Land Ownership
- Protected Lands
- Historic Places
- Wildlife
- Mines
- Contaminated Sites
- Socioeconomic Resources



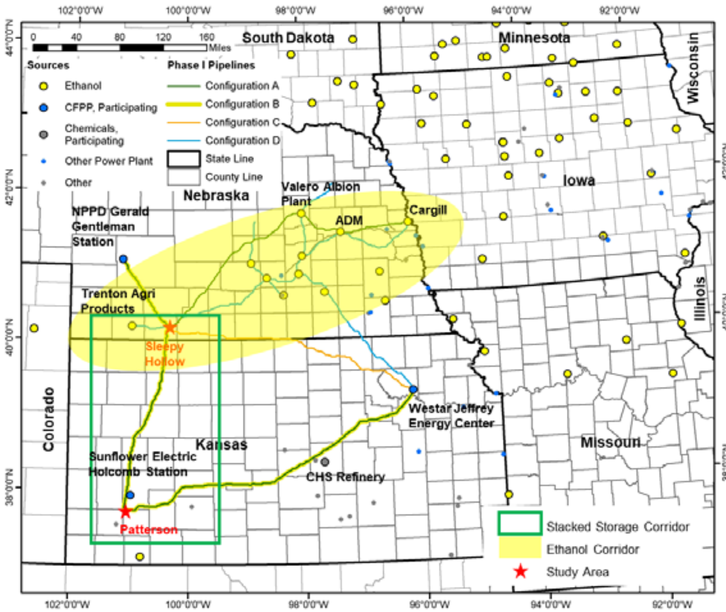
BATTELLE

Updated Pipeline Routes

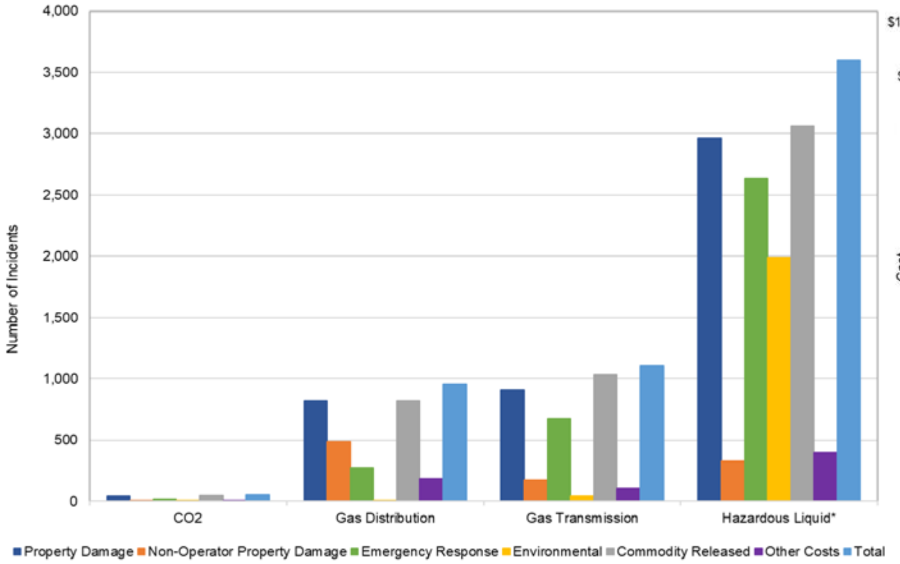
- Pipeline routes, by source, leading to CO_2-EOR sinks (blue), saline sinks (red), and all sinks (black) for (clockwise from top left) all sources, ethanol plants, CFPPs and ethanol plants, and CFPPs alone.



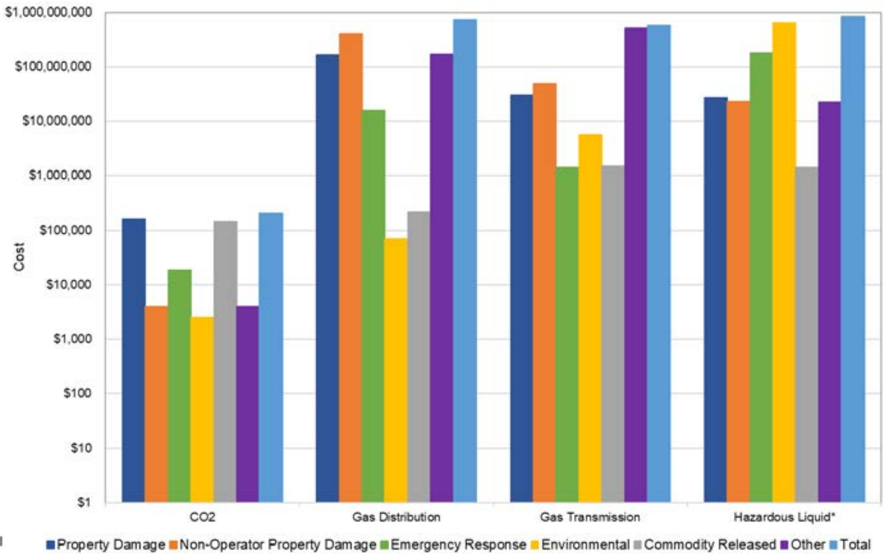
Risk Assessment



Pipeline routes



Number of accidents associated with each type of cost for CO_2, gas distribution, gas transmission, and non-CO_2 hazardous liquids pipelines

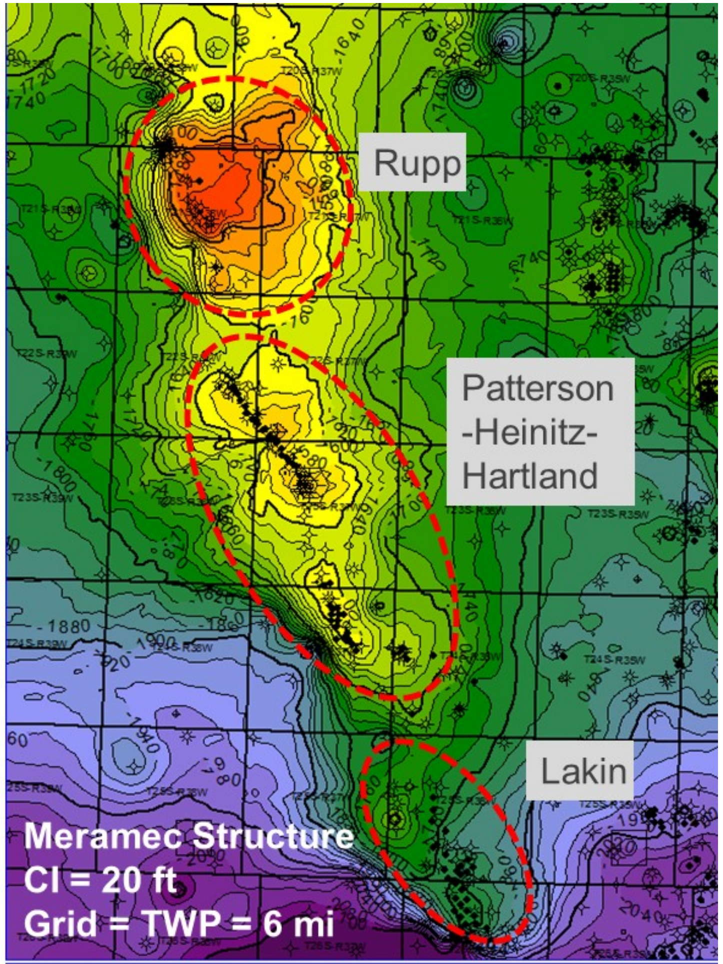


Maximum costs by cost type for CO_2, gas distribution, gas transmission, and non-CO_2 hazardous liquids pipelines.

Config.	Mile-age	CO_2		Gas Distribution		Gas Transmission/Gathering		Non-CO_2 Haz. Liquid	
		Average	Median	Average	Median	Average	Median	Average	Median
a	344	$428,592	$114,025	$576,689	$66,381	$6,283,642	$752,329	$22,524,529	$758,212
b	295	$367,542	$97,783	$494,544	$56,926	$5,388,588	$645,165	$19,316,094	$650,211
c	79	$98,427	$26,186	$132,437	$15,245	$1,443,046	$172,773	$5,172,784	$174,124
d	1546	$1,926,171	$512,448	$2,591,747	$298,331	$28,239,854	$3,381,104	$101,229,426	$3,407,545

Summary

- New Data Collection based on uncertainty and gap assessment is ongoing
  - Sleepy Hollow Field: Characterization well drilled and cemented.   Core, log, and teste data are under analysis or being added to the geologic model
  - Patterson Heinitz Hartland Field: 3D seismic collected for Patterson and Hartland was acquired and is being reprocessed
  - New data will be incorporated to site models to update the number and location of planned injection and monitoring wells allowing an update to the storage costs
- Updated pipeline route model nearly complete that will allow for better estimate of pipeline distances and diameters that will allow better estimate of transport costs
- Risk assessment ongoing and providing practical information for commercialization



BATTELLE

Thank you!

Andrew Duguid

Battelle

Energy Division

505 King Ave

Columbus, Ohio 43201

Duguid@battelle.org

+1 614 561 4468

BATTELLE

Appendix

- These slides will not be discussed during the presentation, but are mandatory.

Benefit to the Program

- The objectives of the IMSCS-HUB program build on the lessons learned from the RCSP's and extend the framework for geologic storage site characterization and development to the commercial scale. The IMSCS HUB Project will systematically address the technical challenges of commercial-scale CO_2 storage and will aid DOE in meeting their Carbon Storage Research and Development Program goals:
- (1) Develop and validate technologies to ensure 99 percent storage permanence.
- (2) Develop technologies to improve reservoir storage efficiency while ensuring containment effectiveness.
- (3) Support industry's ability to predict CO_2 storage capacity in geologic formations to within ±30 percent.
- (4) Develop best practice manuals for site characterization, public outreach, risk management and operations for geologic storage

Introduction

- The Integrated Midcontinent Stacked Carbon Storage Hub plans to gather CO_2 from eastern and central NE and transport it southwest toward Red Willow County, NE along a CO_2-source collection corridor. The CO_2 will then be piped south into central KS along a stacked storage corridor.
- CarbonSAFE Program Objective: Develop a midwestern carbon storage facility having multiple sites with a 50-Mt or greater capacity to safely, permanently, and economically store CO_2 by 2025.

BATTELLE

Phase II IMSCS-HUB Objectives

- Objective 1: Demonstrate multiple 50 Mt storage sites for the IMSCS-HUB concept by evaluating a Kansas and Nebraska site, each with the ability to safely, permanently, and economically store anthropogenic CO_2 through stacked-storage.
- Objective 2: Develop 50 Mt+ storage scenarios and provide a basis for UIC permitting.
- Objective 3: Demonstrate long-term seal integrity and minimize induced seismicity.
- Objective 4: Develop strategies to manage and store CO_2 from multiple sources.
- Objective 5: Leverage the data collected to scale the project to develop a regional commercial enterprise (three to ten 50 Mt+ storage sites).
- Objective 6: Identify and mitigate public outreach and regulatory barriers
- Objective 7: Develop a detailed commercial development plan.

Phase 2 Organization

Sponsors
US Department of Energy
National Energy Technology Laboratory

Dr. Andrew Duguid (Battelle)
Principal Investigator

Steering Committee
Dr. Andrew Duguid (Battelle)
Mr. Scott McDonald (ADM)
Dr. R.M. Joeckel (CSD)
Mr. Dana Wreath (Berexco)
Dr. Tandis Bidgoli (KGS)
Mr. Neil Wildgust (EERC)

Technical Advisor
Dr. Neeraj Gupta (Battelle)

Task 1: Project Management and Planning
Leader: Dr. Andrew Duguid (Battelle)
Project Manager: Mr. Michael Heinrichs (Battelle)

Task 2: Site Access and Permitting
Leader: Mr. Jarred Hawkins (Battelle)

Task 3 Feasibility Data Collection Planning
Co-Leader (Geologic Feasibility): Ms. Isis Fukai (Battelle)
Co-Leader (Reservoir Simulation): Mr. Larry Pekot (EERC)

Task 4: Storage Complex Feasibility Data Collection
Leader: Dr. Andrew Duguid (Battelle)

Task 5 Storage Complex Analysis and Modeling
Co-Leader (Geologic Characterization): Ms. Isis Fukai (Battelle)
Co-Leader (Reservoir Simulation): Mr. Larry Pekot (EERC)

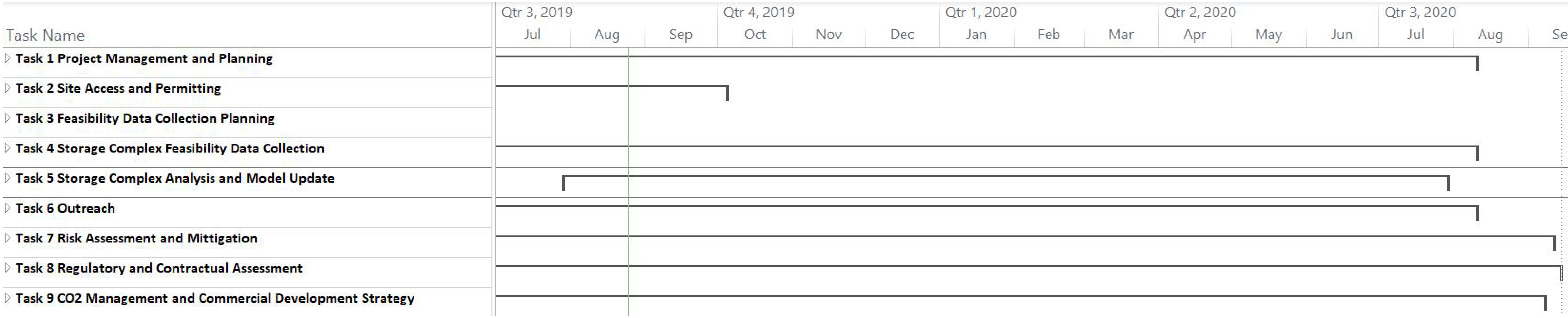
Task 6: Outreach
Task Leader: Brendan Jordan (GPI)

Task 7: Risk Assessment and Mitigation
Leader: Dr. Heather McCarren (Battelle)

Task 8: Regulatory and Contractual Requirements Assessment
Co-Leader: Mr. Scott McDonald (ADM)
Co-Leader: Dr. Tandis Bidgoli (KGS)

Task 9: CO_2 Management and Commercial Development Strategy
Co-Leader: Dr. Andrew Duguid (Battelle)
Co-Leader: Mr. Scott McDonald (ADM)

Gantt Chart


Task Name
Qtr 3, 2019
Qtr 4, 2019
Qtr 1, 2020
Qtr 2, 2020
Qtr 3, 2020
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Se
Task 1 Project Management and Planning
Task 2 Site Access and Permitting
Task 3 Feasibility Data Collection Planning
Task 4 Storage Complex Feasibility Data Collection
Task 5 Storage Complex Analysis and Model Update
Task 6 Outreach
Task 7 Risk Assessment and Mittigation
Task 8 Regulatory and Contractual Assessment
Task 9 CO2 Management and Commercial Development Strategy