
EERC
Critical Challenges.
Practical Solutions.

NEBRASKA INTEGRATED CARBON CAPTURE AND STORAGE PRE-FEASIBILITY STUDY

DE-FE0029186

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Energy & Environmental Research Center

U.S. Department of Energy

National Energy Technology Laboratory

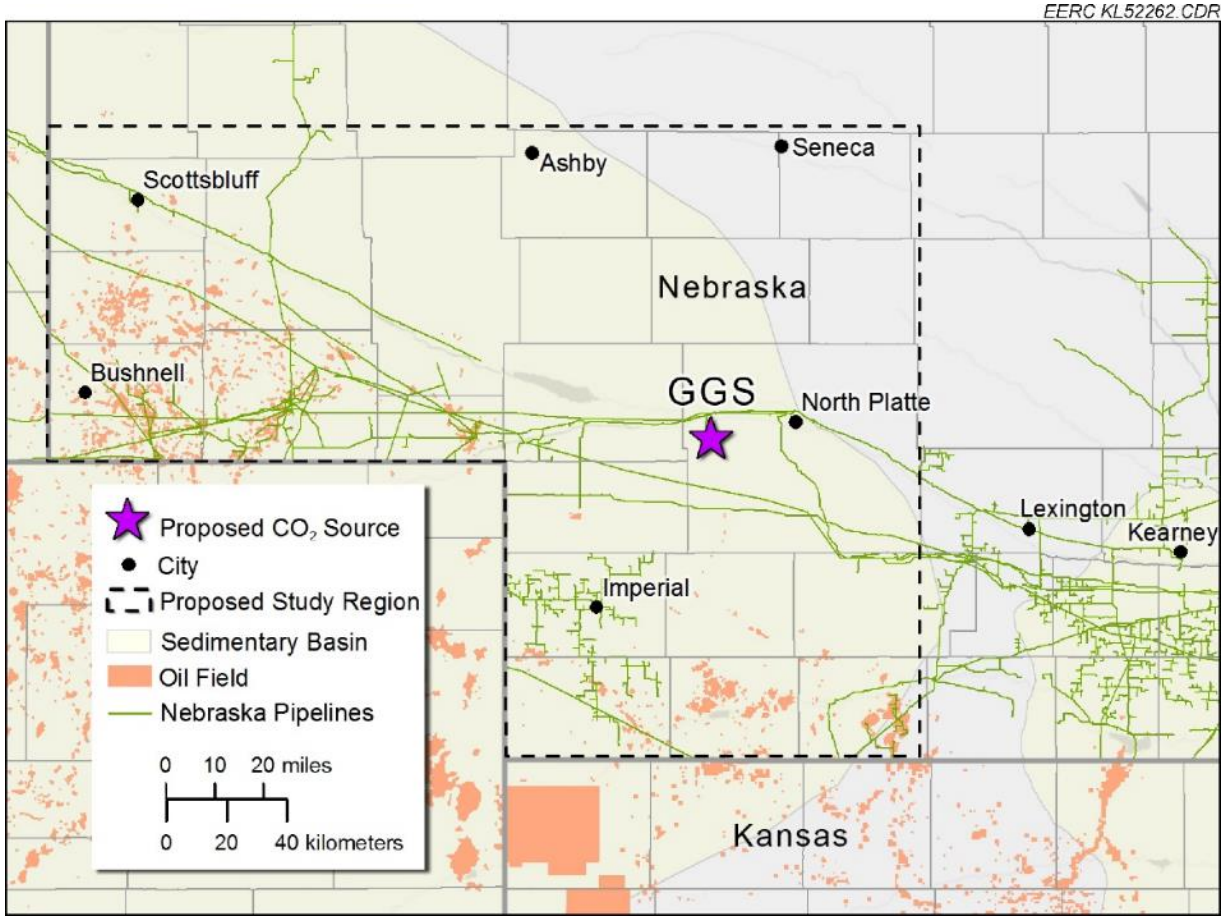
Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration:
Carbon Storage and Oil and Natural Gas Technologies Review Meeting

August 1–3, 2017

Critical Challenges. Practical Solutions.

TASK AND SUBTASK BREAKDOWN

- *Task 1.0 – Project Management, Planning, and Reporting*
- **Task 2.0 – Regional and Stakeholder Analysis**
- **Task 3.0 – Scenario Analysis**
- **Task 4.0 – Subbasinal Analysis**
- *Task 5.0 – NRAP Validation*

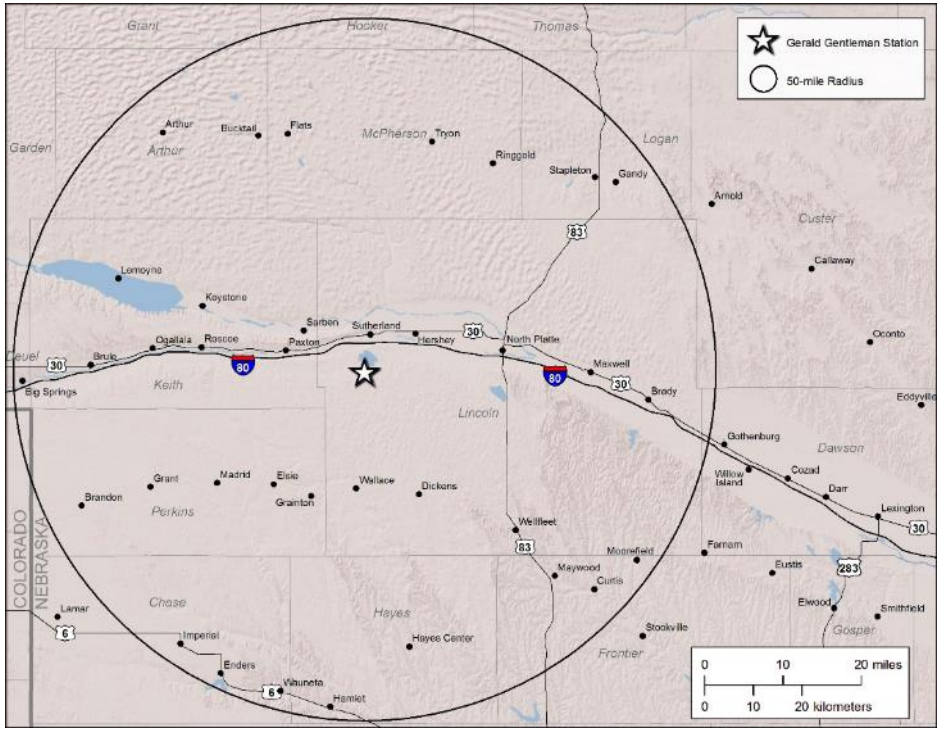


TASK 2.0 – REGIONAL AND STAKEHOLDER ANALYSIS

Assessment of geographic and socioeconomic characteristics specific to the study region in relation to carbon capture and storage (CCS):

- Subtask 2.1 – Analysis of Environmentally Sensitive Areas
  - Identified protected/environmentally sensitive areas (e.g., wildlife preserves) within a 50-mile radius of Gerald Gentleman Station, Sutherland, Nebraska
    - ♦ Assessed for potential conflicts related to CCS operations

- Subtask 2.2 – Investigation of Potential Impact on Current and Future Resource Development
  - Identify existing and future resource development, mineral rights, infrastructure (e.g., pipelines, rights of way [ROW], etc.)
  - Assess for potential impacts related to CCS operations



TASK 2.0 – REGIONAL AND STAKEHOLDER ANALYSIS, cont.

Assessment of geographic and socioeconomic characteristics specific to the study region in relation to CCS:

- Subtask 2.3 – Community Impact Analysis
  - Regional demographics
  - Regional public perception and understanding of CCS and related issues
  - Local economic and industrial trends
  - Identify pore space and surface owners
  - ➢ Community Outreach Plan
    - ♦ Educate/inform the public, public opinion leaders, and decision makers
    - ♦ Methods to evaluate public perception of CCS and mitigation approaches to any identified potential conflicts

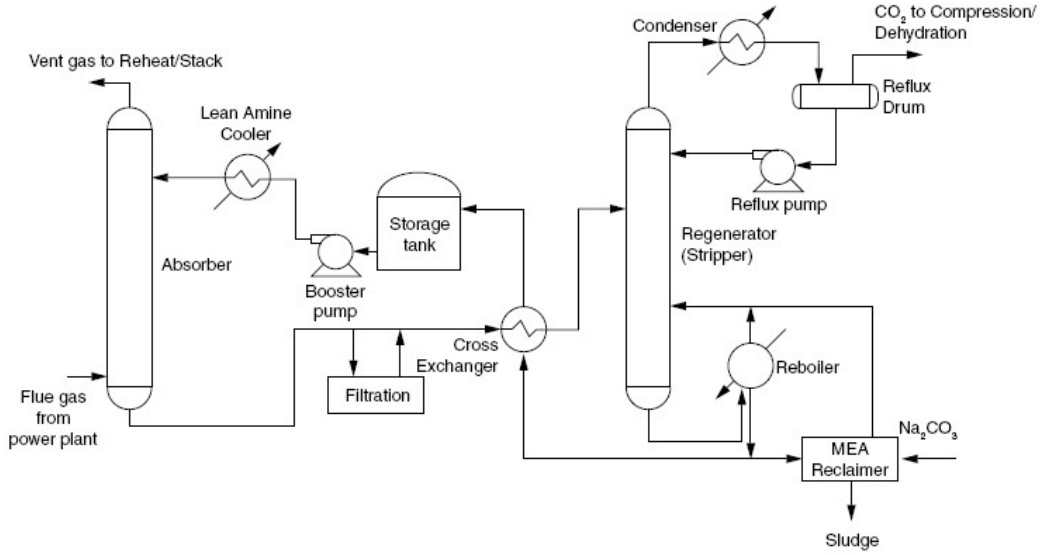
STAKEHOLDER KICKOFF MEETING, JULY 18, LINCOLN, NEBRASKA

- Presented by EERC (project manager) and Nebraska Public Power District (NPPD) (utility partner)
- 27 attendees
  - Nine representing project management, technical team, and utility partner
  - 18 representing range of interested parties
    - Policy and regulatory
    - Oil production
    - Electricity generation
    - Ethanol production
    - University
    - Capture technology
- CCS basics, CarbonSAFE-Nebraska project details, and attendee perspectives

TASK 3.0 – SCENARIO ANALYSIS

Current Activities:

- Subtask 3.1 – CO_2 Resource Assessment
  - Using the EPA Facility Level Information on GreenHouse Gases Tool (FLIGHT), searched for all major point sources emitting more than 100,000 tonnes CO_2/yr within a 50-mi radius of Sutherland, Nebraska.
  - NPPD's Gerald Gentleman Station is the only one.
  - Determined that solvent scrubbing is the capture technology most likely to be used. Current technical details on the most promising commercial CO_2 capture solvents are being researched.



NPPD'S GERALD GENTLEMAN STATION UNIT 2

Nebraska Public Power District
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Gerald Gentleman Station Unit 2 (GGS2) will be assumed to provide the CO_2 for this prefeasibility study.

2016 statistics (from EPA Air Markets Program data):

- Dry bottom, wall-fired boiler
- Low-NO_x burners with overfired air
- Baghouse for particulate control
- Halogenated powdered activated carbon (PAC) injection for mercury control
- Gross load = 3,609,063 MWh
- CO_2 emission = 3.24 million tonnes

PRELIMINARY INTEGRATED ENVIRONMENTAL CONTROL MODEL (IECM) MODELING RESULTS

- **Major Assumptions:**
  - Capture takes place at GGS2 as a retrofit on NPPD-owned property.
  - All capture types require installation of a wet flue gas desulfurization (WFGD) unit with a demister.
  - Pipeline would be 50 mi in length.
  - CO_2 pressure at plant = 2000 psi; at injection site = 1500 psi.
  - Use of a flue gas bypass and a 47% overall CO_2 removal efficiency produces 2 million tonnes of CO_2 for injection each year.

Capture Type	Total Levelized Annual Cost, M$/yr (2014$)
Baseline	173.9
Baseline + WFGD/demister	200.0
Fluor Econamine FG+	259.4
Cansolv	288.8
Monoethanolamine (MEA)	278.4
Ammonia	284.1
Polymer Membrane	289.4

TASK 3.0 OTHER ACTIVITIES

Subtask 3.2 – Financial and Economic Evaluation

- GGS2 is being modeled using Carnegie Mellon IECM V9.5 to provide estimates of the cost associated with capturing, compressing, and transporting 2 million tonnes/yr CO_2.
- Capital and operating costs are being estimated using the model.

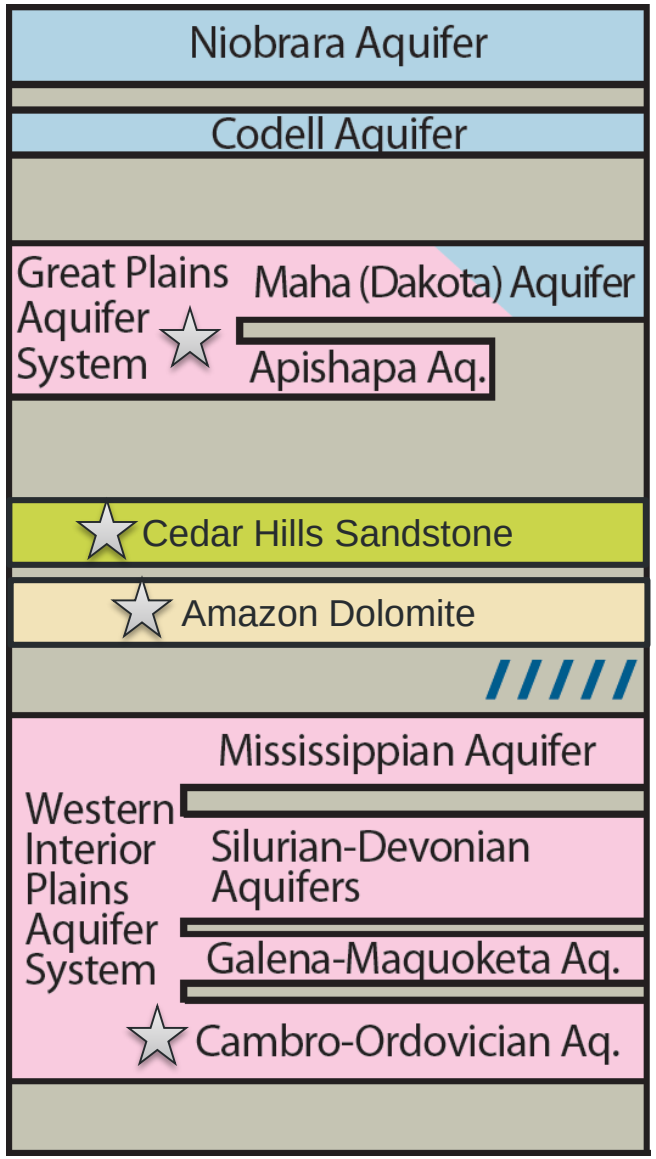
- Subtask 3.3 – State and Federal Incentives and Challenges
  - Identifying policies and permitting requirements specific to Nebraska.
- Subtask 3.4 – Storage Resources Ownership Evaluation
  - Determining the pore space rights in Nebraska.

TASK 4.0 SUBSURFACE ASSESSMENT

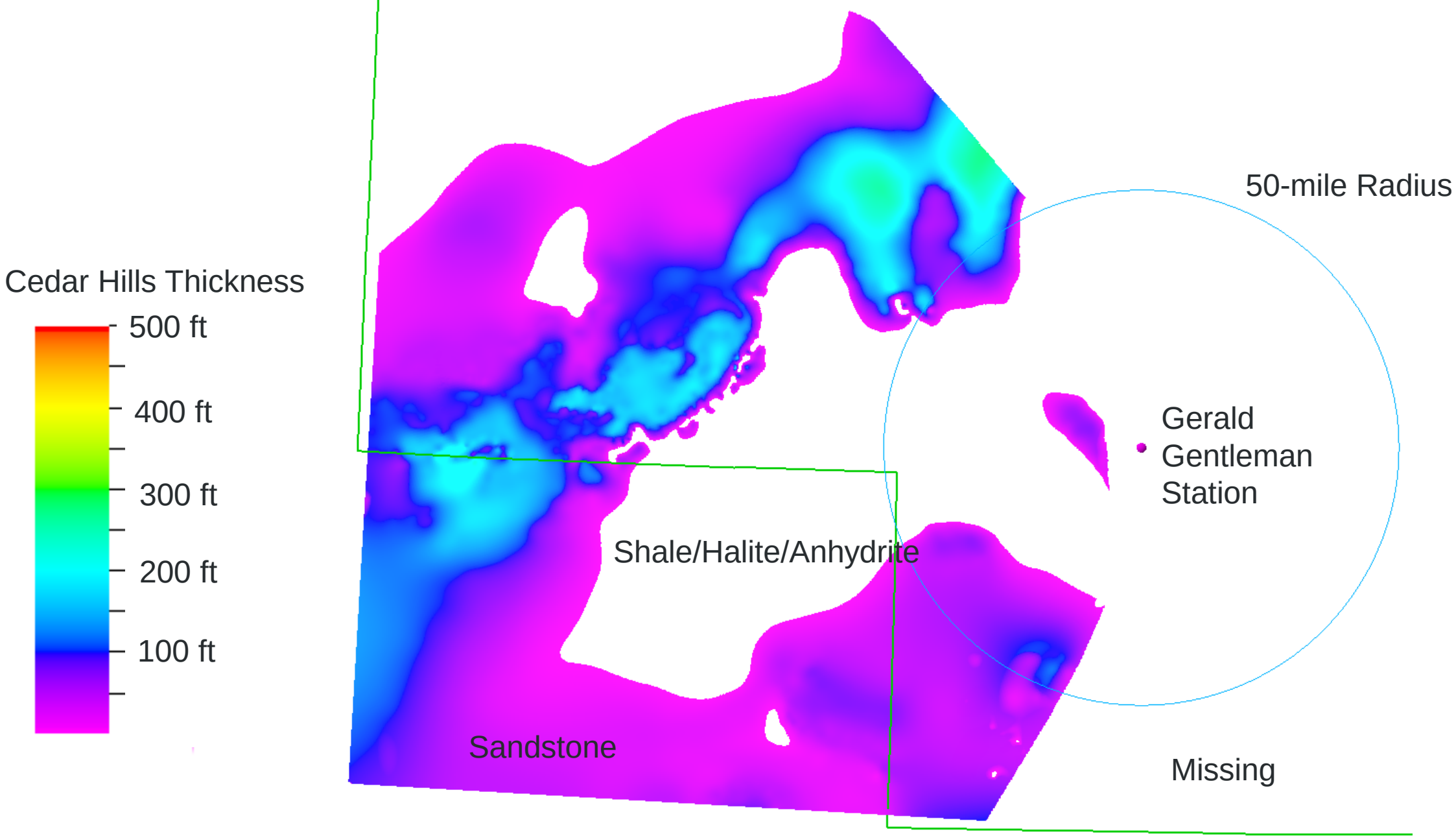
Evaluation of potential geologic storage locations:

- Examine geologic storage targets
- Identify reservoirs capable of 50+ million tonnes CO_2 storage and potential injection sites (including EOR)
- Determine the area of review (AOR) – surface and subsurface
- Articulate additional data needs

→ **Characterization Plan**



Paleozoic and Mesozoic Aquifers in Nebraska (Korus and Joeckel, 2011; mod.)


Cedar Hills Thickness
500 ft
400 ft
300 ft
200 ft
100 ft
50-mile Radius
Gerald Gentleman Station
Shale/Halite/Anhydrite
Sandstone
Missing

TASK 5.0 – NRAP VALIDATION

- **Objectives**
  - Assessment of National Risk Assessment Partnership (NRAP) tools, providing feedback to DOE and the NRAP team
    - ♦ Select NRAP tools that will be used to independently both simulate long-term leakage and calculate CO_2 and pressure plumes through time.
    - ♦ Other NRAP tools will be used if applicable.

- **Tools selected for an initial assessment**
  - Reservoir Reduced-Order Model – Generator (RROM-Gen) tool — **Validated**
  - Reservoir Evaluation and Visualization (REV) tool — **Validated**
  - Well Leakage Analysis Tool (WLAT) — **Ongoing work**

PROJECT SUMMARY

- Synergy opportunities: informal discussions to date with two other CarbonSAFE Phase I projects in the Nebraska/Kansas region.
- Strong interest from stakeholders in understanding CCS potential in Nebraska – positive engagement at kickoff meeting in July.
- Significant geological uncertainty – sparse deep well records.
- Distribution of prospective deep saline formation (DSF) storage resources in Nebraska appears uneven.

ACKNOWLEDGMENT

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Disclaimer

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THANK YOU!

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APPENDIX

PROJECT OVERVIEW: BENEFIT TO THE PROGRAM

Benefits Statement

This project provides a solution to mitigation of CO_2 emissions from coal-fired electricity generation through investigation of CO_2 capture from flue gas and subsequent permanent geologic storage. The approach described in this pre-feasibility study advances carbon storage research and development by identifying commercial-scale geologic storage sites and generating a pathway to implementation that will be socially acceptable and meet all permitting requirements, including the formation of an engaged, highly qualified CCS coordination team. In addition, the proposed research supports the **DOE Carbon Storage Program's goals** to **"develop and validate technologies to ensure 99 percent storage permanence" [Goal 1]** and to **"develop technologies to improve reservoir storage efficiency while ensuring containment effectiveness" [Goal 2]** by conducting the proposed subbasinal characterization and by utilizing site-screening tools such as NRAP. The DOE program goal to **"support industry's ability to predict CO_2 storage capacity in geologic formations to within ±30 percent" [Goal 3]** will be addressed by integrating characterization data into reservoir models for a commercial-scale geologic storage facility (≥50 million metric tons CO_2). Information produced will be useful for inclusion in **DOE's Carbon Storage best practices manuals**, the development of which is also a DOE program goal **[Goal 4]**.

PROJECT OVERVIEW: GOALS AND OBJECTIVES

- Goal: To determine the feasibility of integrating commercial-scale capture of industrially sourced CO_2 emissions from NPPD's Gerald Gentleman Station (GGS) with subsequent storage at a proximate geologic site in western Nebraska safely, permanently, and certifiably.

- Objectives
  - Establish a CCS coordination team for the Nebraska effort. [*Goal 4*]
  - Develop a plan to address the challenges of a potential commercial-scale CCS project in western Nebraska. [*Goal 4*]
  - Conduct a high-level, technical subbasinal evaluation in western Nebraska and a CO_2 source assessment at GGS and other CO_2-emitting facilities. [*Goals 1–4*]

METHODOLOGY: ADVISORY BOARD FOR CCS

Nebraska Oil and Gas Con

EERC

Nebraska Public Power District
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NEBRASKA ENERGY OFFICE
Good Life. Great Energy.

Schlumberger Carbon Services

ION ENGINEERING

Nebraska Department of Environmental Quality

CMG COMPUTER MODELLING GROUP LTD.

University of Nebraska Lincoln

BEREXCO

SWPPD SOUTHWEST PUBLIC POWER DISTRICT

your energy partner® OPPD Omaha Public Power District

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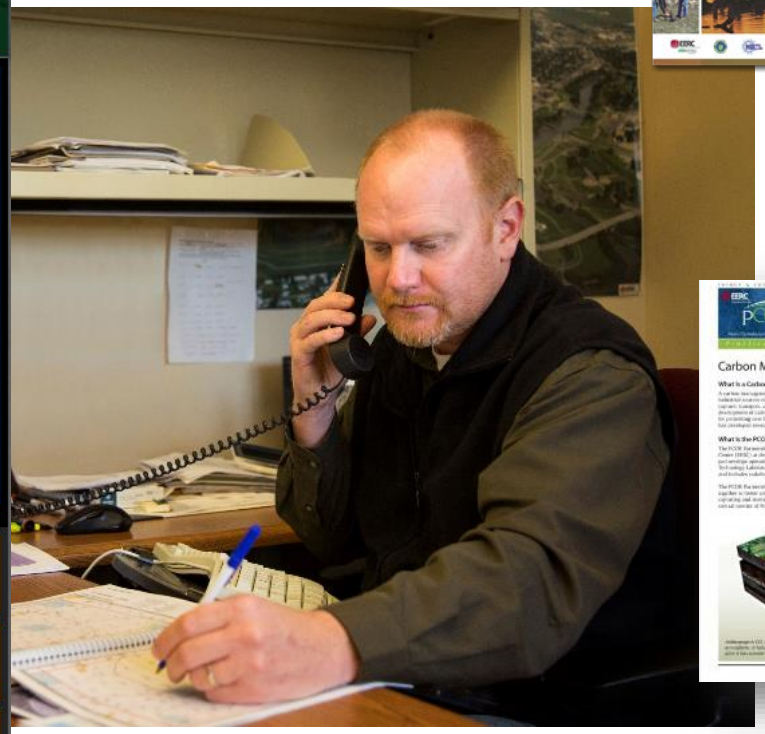
METHODOLOGY: CCS EXPERTISE

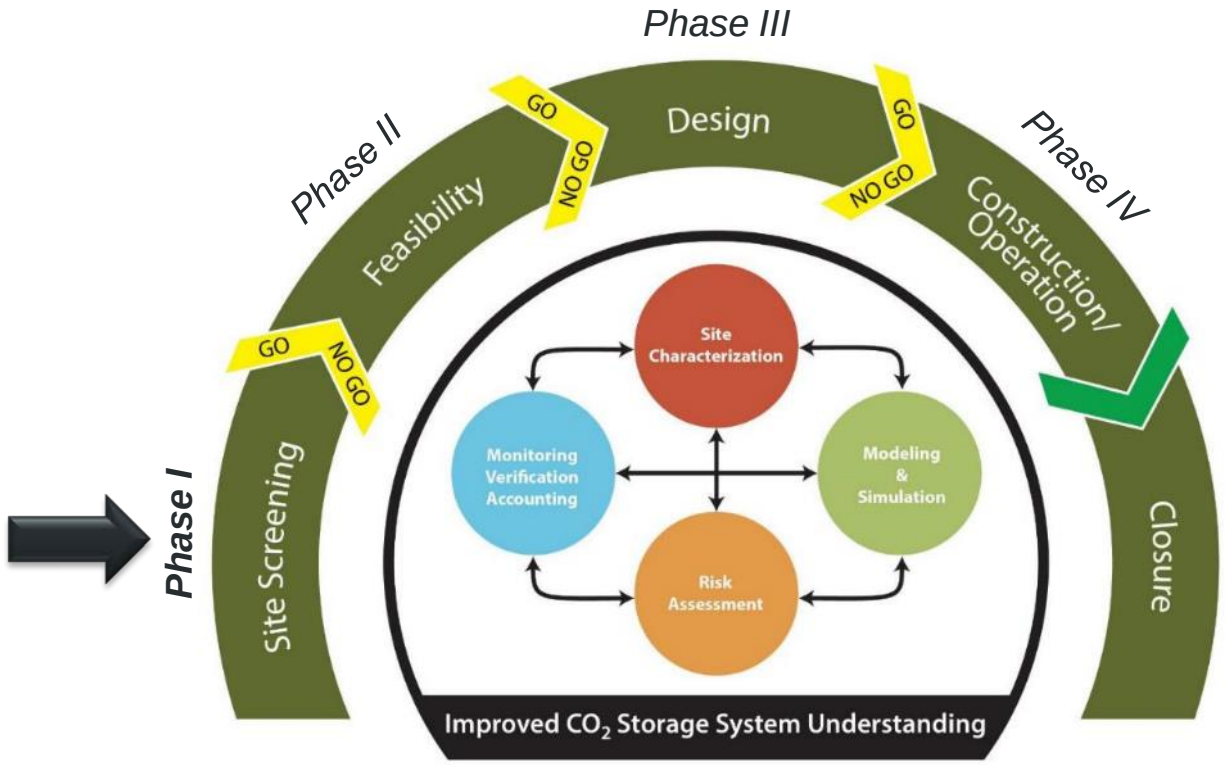
- Partnership for CO_2 Capture (PCO_2C)
- 8-year program (2008–2016)

- Plains CO_2 Reduction (PCOR) Partnership
- +13-year program (2003–present)

METHODOLOGY: OUTREACH

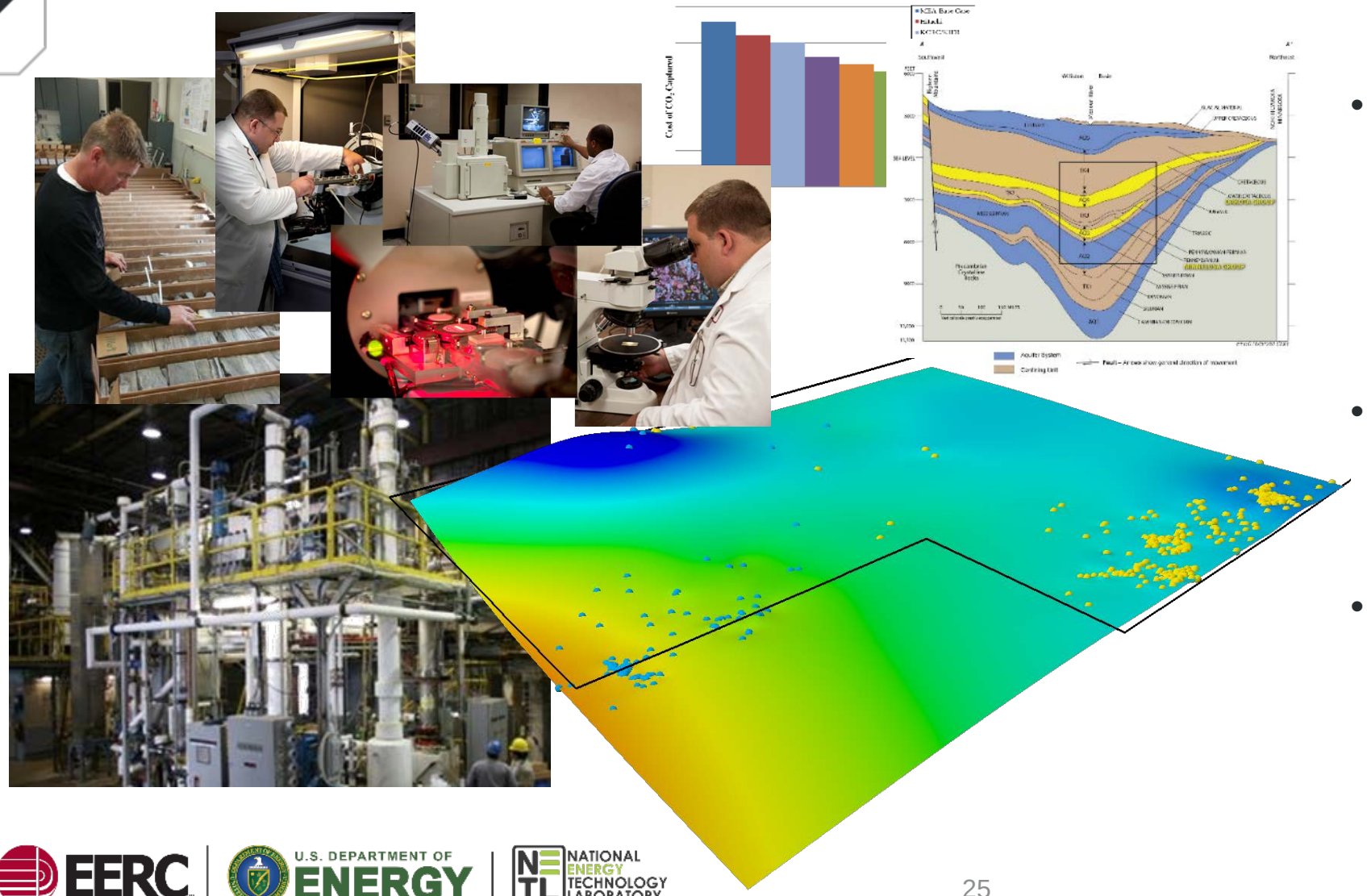


METHODOLOGY: ESTABLISHED METHODS



- The EERC has developed an adaptive approach to project management and execution.
  - Integrates multidisciplinary teams
  - Integrates data across project teams
- Technical methodologies developed and applied include the following:
  - Geologic modeling and reservoir simulation
  - Risk assessment
  - Monitoring, verification, and accounting (MVA)
  - Site characterization activities related to CCS
- Designed, drilled, and completed over one dozen wells for characterization and monitoring of CCS validation and demonstration projects.
- Shared lessons learned with industry and public.

METHODOLOGY: BUILDING FROM EXISTING DATA



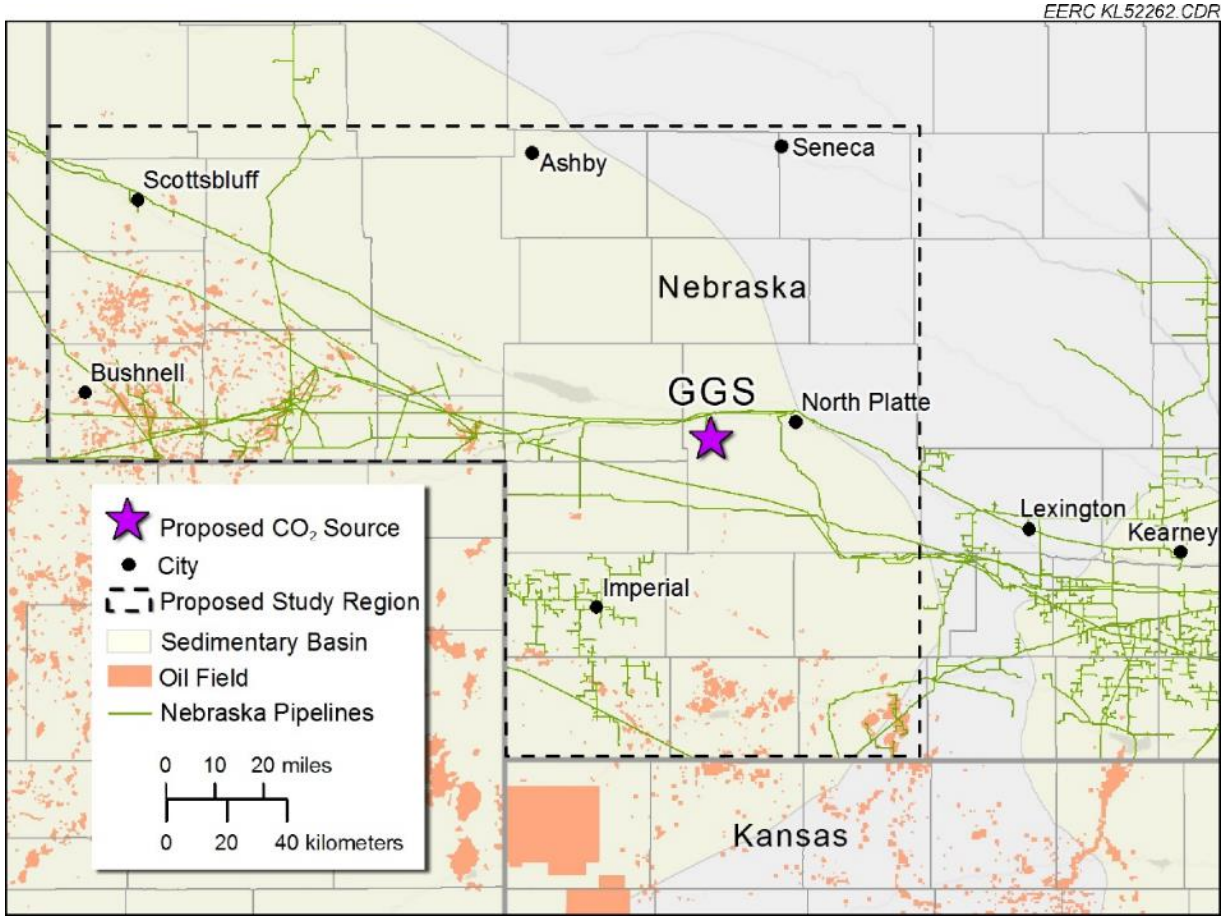
- The EERC has conducted many site characterization projects in the Great Plains for both private and public entities:
  - Carbon management plans
  - CO_2 injection studies
- The EERC has significant inventory of site characterization data and experience as a result of these activities.
- The EERC has direct experience with evaluating CO_2 capture technologies and understanding of challenges to implementation.

EXPECTED OUTCOMES

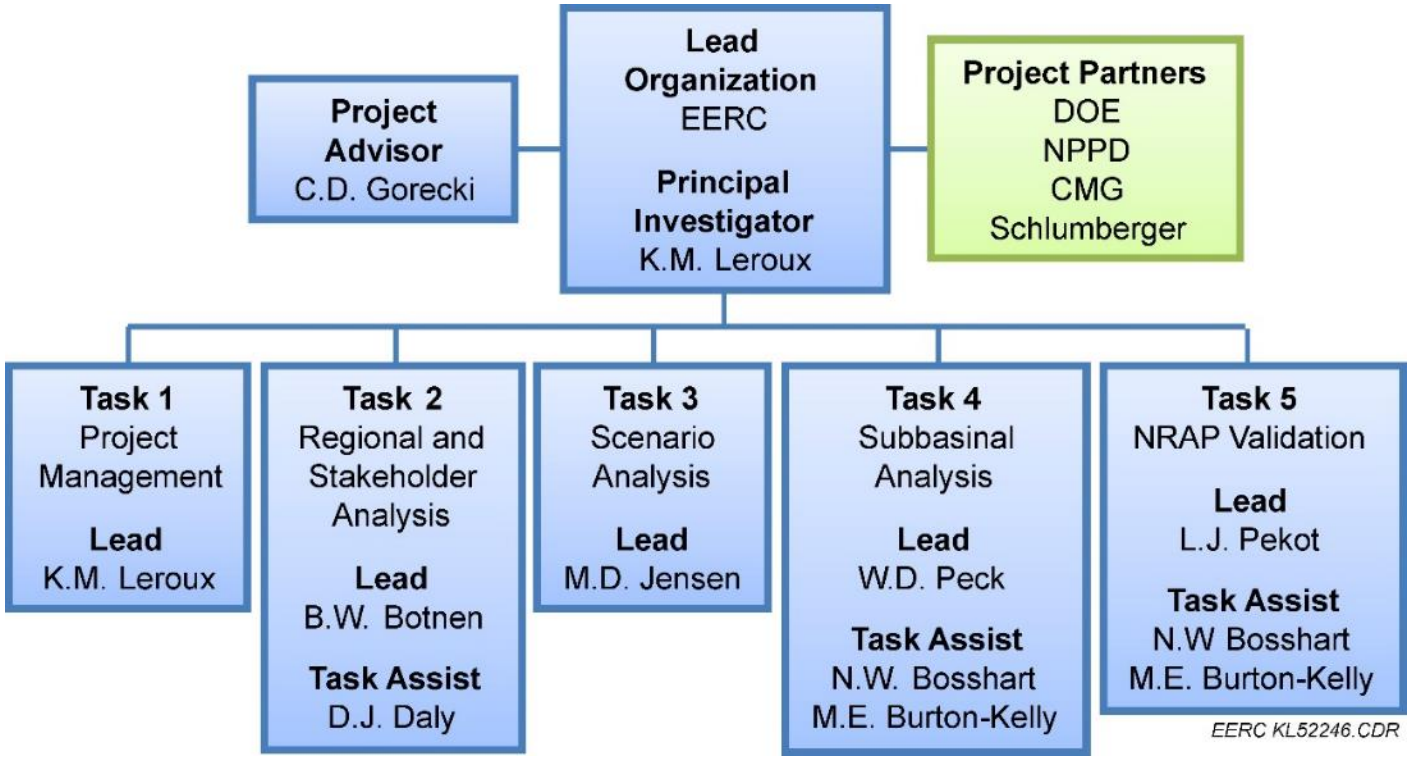
- Sufficient information to move forward with a Phase II feasibility effort.
  - Final technical report
  - Journal article or technical paper draft
  - Generated data → NETL Energy Data eXchange (EDX)
- Establishment of a CCS coordination team for the Nebraska effort.
- Plans addressing potential challenges for CCS in western Nebraska.
  - Community outreach plan
  - Financial plan
- Completion of high-level, technical subbasinal and CO_2 source evaluations for the Nebraska effort.
  - Future characterization plan

TASK AND SUBTASK BREAKDOWN

- Task 1.0 – Project Management, Planning, and Reporting
- Task 2.0 – Regional and Stakeholder Analysis
- Task 3.0 – Scenario Analysis
- Task 4.0 – Subbasinal Analysis
- Task 5.0 – NRAP Validation



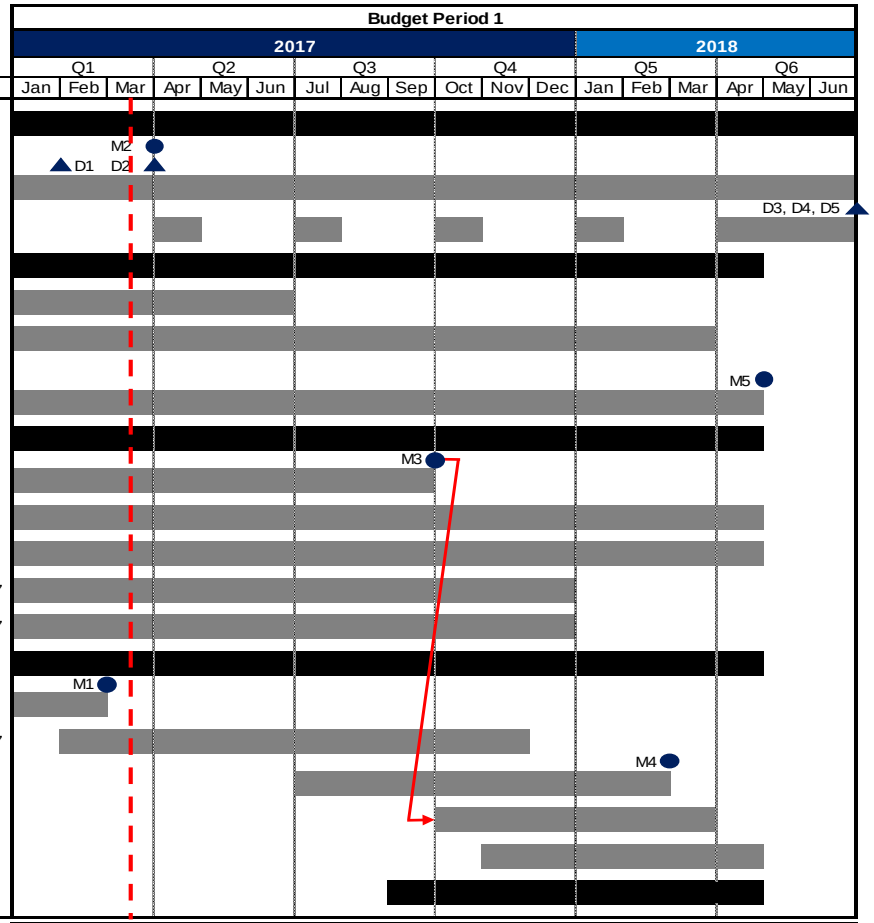
ORGANIZATION CHART/COMMUNICATION PLAN



- Regular update meetings with project team.
- Communication with partners/consultants via conference call, e-mail, Webinar, and in-person meetings.
- Quarterly reports and annual briefings to DOE.
- Major decisions affecting scope, budget, or time line will be discussed with the DOE project manager.

PROPOSED SCHEDULE

	Start	End
Task 1.0 – Project Management, Planning, and Reporting	**1/1/17**	**6/30/18**
1.1 – Project Management and Planning	1/1/17	6/30/18
1.2 – Project Reporting	4/1/17	6/30/18
Task 2.0 – Regional and Stakeholder Analysis	**1/1/17**	**4/30/18**
2.1 – Analysis of Environmentally Sensitive Areas	1/1/17	6/30/17
2.2 – Investigation of Potential Impact on Current and Future Resource Development	1/1/17	3/31/18
2.3 – Community Impact Analysis	1/1/17	4/30/18
Task 3.0 – Scenario Analysis	**1/1/17**	**4/30/18**
3.1 – CO_2 Resource Assessment	1/1/17	9/30/17
3.2 – Financial and Economic Evaluation	1/1/17	4/30/18
3.3 – State and Federal Incentives and Challenges	1/1/17	4/30/18
3.4 – Storage Resource Ownership Evaluation	1/1/17	12/31/17
3.5 – Long-Term Liability	1/1/17	12/31/17
Task 4.0 – Subbasinal Analysis	**1/1/17**	**4/30/18**
4.1 – Reservoir and Seal Characteristics	1/1/17	2/28/17
4.2 – Storage Resource Assessment	2/1/17	11/30/17
4.3 – AOR Development	7/1/17	2/28/18
4.4 – CO_2 Source Evaluation	10/1/17	3/31/18
4.5 – Plans for Future Characterization	11/1/17	4/30/18
Task 5.0 – NRAP Validation	**9/1/17**	**4/30/18**



Task Duration
Subtask Duration
Critical Path

Deliverables (D)	Milestones (M)
D1 – Updated Project Management Plan (PMP)	M1 – Evaluation of Reservoir and Seal Characteristics Completed
D2 – Updated Data Management Plan (DMP)	M2 – Project Kickoff Meeting
D3 – Final Technical Report	M3 – Assessment of CO_2 Resources Completed
D4 – Draft Journal or Technical Paper	M4 – Completion of Risk Assessment
D5 – Data Submitted to NETL EDX	M5 – Completion of Community Outreach Plan

DELIVERABLES, MILESTONES, AND DECISION POINTS

Deliverables/Reports

ID	Title/Description	Planned Completion Date
D1	Project Management Plan	Updated as necessary/ requested
D2	Data Management Plan	Updated as necessary/ requested
D3	Final Technical Report	6/30/18
D4	Journal Article or Technical Paper Draft	6/30/18
D5	Data Submitted to NETL EDX	6/30/18

Milestones

Title/Description	Related Subtask	Planned Completion Date	Verification Method
*M1 – Evaluation of Reservoir and Seal Characteristics Completed	4.1 – Reservoir and Seal Characteristics	2/28/17	Reported in subsequent quarterly report
M2 – Project Kickoff Meeting Held	1.1 – Project Management and Planning	3/31/17	Presentation file submitted to DOE
*M3 – Assessment of CO_2 Resources Completed	3.1 – CO_2 Resource Assessment	9/30/17	Reported in subsequent quarterly report
M4 – Completion of Risk Assessment	4.3 – AOR Development	2/28/18	Reported in subsequent quarterly report
M5 – Completion of Community Outreach Plan	2.3 – Community Impact Analysis	4/30/18	Reported in subsequent quarterly report

*Decision points

SUCCESS CRITERIA

- Subtask 4.1 – Reservoir and Seal Characteristics. A list of potential saline formations in western Nebraska will be generated and ranked on applicability for commercial-scale CO_2 storage (M1), allowing for initiation of Subtask 4.2 – Storage Resource Assessment.
- Subtask 3.1 – CO_2 Resource Assessment. An investigation of industrial CO_2 sources in western Nebraska will be conducted (M3), allowing for initiation of Subtask 4.4 – CO_2 Source Evaluation.
- Subtask 4.3 – Area of Review (AOR) Development. A risk assessment will be conducted to identify potential constraints with candidate reservoirs serving as commercial storage sites and provide a mitigation plan (M4).
- Subtask 2.3 – Community Impact Analysis. A community outreach plan will be developed to educate/inform the public, leaders, and decision makers, incorporating methods to evaluate public perception of CCS and to mitigate any potential conflicts (M5).
- A final technical report (D3) will be prepared and submitted.

RISK MATRIX

Category	Potential Risk	Mitigation
Technical Difficulties	Insufficient data or loss of data	• Large in-house geological database. Large amount of public data easily available. • Workstations and servers backed up.
	Issues with reservoir-modeling and simulation software	• Extensive expertise and familiarity. • Working history with vendors and support services.
Resource Availability	Insufficient computing capability	• Multiple existing computer stations. • High-performance computing cluster.
	Lack of personnel	• Cross-training and redundancy in skill sets. • Senior management overseeing personnel and resource availability.
Environmental, Health, and Safety (EHS)	Personal injury	• No fieldwork component in this Phase 1 effort.
	Environmental impact	• Scope of work includes only analysis and interpretation of the collected data.
Management Issues	Inability to manage large-scale project	• Majority of work conducted at the EERC facility, allowing regular interaction and communication with project team members. • Planning meetings held before fieldwork. • Proven working relationship with consultants and project partner. • Existing standardized workflow processes, communication protocols, and contractual procedures. • Working knowledge of managing similar-scale resource assessment and oil- and gas-related projects.

APPENDIX: FUNDING TABLES

Baseline Project Cost by Task

Task No.	Cost, $
1.0	167,538
2.0	367,864
3.0	242,755
4.0	955,734
5.0	51,993
Total	1,785,884

Funding Profile by Recipient Organization

	BP1	
Recipient Organization	DOE, $	Nonfederal Cost Share, $
EERC	1,244,473	541,411

Funding Profile by Cost-Sharing Partner

Funding Source	Type	BP1, $
DOE	Cash	1,244,473
NPPD*	Cash	47,031
NPPD	In-kind	25,000
CMG, Ltd.	In-kind	169,380
Schlumberger	In-kind	300,000
Total		1,785,884

*NPPD will provide $50,000 of cash cost share as indicated in its letter of commitment. However, only $47,031 can be recognized by DOE as cost share because of a differential in the F&A rate applied to nonfederal sponsors.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