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January 27, 2017

Ms. Karlene Fine
Executive Director
ATTN: Lignite Research Program
North Dakota Industrial Commission
600 East Boulevard Avenue
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: EERC Proposal No. 2017-0076 Entitled "North Dakota Integrated Carbon Storage Complex Feasibility Study"

The Energy & Environmental Research Center (EERC) of the University of North Dakota is pleased to submit an original and one copy of the subject proposal. Also enclosed is the $100 application fee. The EERC is committed to completing the project as described in the proposal if the Commission makes the requested grant.

If you have any questions, please contact me by telephone at (701) 777-5195 or by e-mail at wpeck@undeerc.org.

Sincerely,

Wesley D. Peck
Principal Geologist, Geosciences Group Lead

Approved by:

for Tom Erickson

Thomas A. Erickson, CEO
Energy & Environmental Research Center

WDP/bjr

Enclosures

Lignite Research Program

North Dakota Industrial Commission

Application

Project Title: North Dakota Integrated Carbon Storage Complex Feasibility Study

Applicant: University of North Dakota Energy & Environmental Research Center

Principal Investigator: Wesley D. Peck

Date of Application: January 27, 2017

Amount of Request: $1,500,000.00

Total Amount of Proposed Project: $13,857,978

Duration of Project: 24 months

Point of Contact (POC): Wesley D. Peck

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POC Address: 15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

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ABSTRACT

The Energy & Environmental Research Center (EERC) has received an award notification under the U.S. Department of Energy's (DOE's) CarbonSAFE Program to conduct a project entitled North Dakota Integrated Carbon Storage Complex Feasibility Study. This project will determine the feasibility of developing a commercial-scale CO_2 geologic storage site capable of safely, permanently, and economically storing 50+ million metric tons (Mt) of CO_2 in central North Dakota. Two ideal geologic storage sites adjacent to separate lignite-fired facilities will be evaluated: the Basin Electric Power Cooperative-owned Dakota Gasification Company Great Plains Synfuels Plant and the Minnkota Power Cooperative-owned Milton R. Young Station. These locations, one with readily available captured CO_2, are bolstered by an existing CO_2 pipeline and progressive North Dakota pore space ownership and long-term liability laws. These elements create synergistic scenarios for promoting North Dakota's statewide vision for carbon management and ensuring the success of the CarbonSAFE Program. Results of this project will greatly reduce uncertainties regarding the development of a CO_2 geologic storage project in a deep saline environment, such as understanding the spatial extent needed to store 50 Mt of CO_2 and the related magnitude of future pore space-leasing requirements. Risk assessment activities will identify potential critical issues specific to establishing a qualified commercial-scale storage site and develop mitigation options to address the issues. Public outreach efforts will communicate the project goals, activities, and benefits to the public at large throughout the performance period. Those efforts will also bring into focus the societal perspectives of the local region with respect to establishing an active CO_2 storage project and formulate mitigation strategies to ensure continued use of North Dakota's lignite resources. The EERC will conduct the project over the course of 2 years. The total value of the project is $13,857,978, of which the North Dakota Industrial Commission Lignite Research Council is being asked to contribute $1,500,000. In addition, DOE and several public and private entities have pledged financial and in-kind support for the planned effort. Participants include Basin Electric Power Cooperative, ALLETE Clean Energy, BNI Energy, North American Coal, Minnkota Power Cooperative, Prairie Public Broadcasting, Computer Modelling Group, and Schlumberger Carbon Services.

PROJECT SUMMARY

The Energy & Environmental Research Center (EERC) is a recent award recipient under the U.S. Department of Energy's (DOE's) CarbonSAFE (Carbon Storage Assurance Facility Enterprise) Program. The primary objective of the successfully proposed project, entitled North Dakota Integrated Carbon Storage Complex Feasibility Study, is to establish the geologic, economic, regulatory, and social feasibility of developing a commercial-scale (50+ million metric tons [Mt]) geologic CO_2 storage site to promote North Dakota's statewide vision for lignite use and carbon management and fulfill the goals of DOE's CarbonSAFE Program. Acquisition of geologic data specific to addressing that objective will reduce the technical and nontechnical uncertainty with respect to the ultimate implementation of a commercial-scale operation. This feasibility study will evaluate two ideal geologic storage sites in the Broom Creek Formation, located adjacent to separate coal-fired facilities in North Dakota: the Basin Electric Power Cooperative (BEPC)-owned Dakota Gasification Company (DGC) Great Plains Synfuels Plant and the Minnkota Power Cooperative (MPC)-owned Milton R. Young (MRY) Station (Figure 1). These locations, one with readily available CO_2, are bolstered by an existing CO_2 pipeline and progressive North Dakota pore space ownership and long-term liability laws. These promising CO_2 geologic storage sites, in combination with the motivated team, create an ideal synergistic scenario for ensuring success of the CarbonSAFE Program, promoting North Dakota's statewide vision for carbon management, and supporting the long-term, continued use of North Dakota's lignite resources.

This project will implement the best practices founded on the research conducted through DOE's Regional Carbon Sequestration Partnerships (RCSP) Program, which includes the EERC-led Plains CO_2 Reduction (PCOR) Partnership. As an example, the RCSPs and the PCOR Partnership have developed methods and best practices for site selection and characterization of a suitable CO_2 storage location (U.S. Department of Energy, 2010). Assessing the feasibility of any potential CO_2 storage location is a comprehensive, iterative approach refined as new information is discovered. For example, planned core

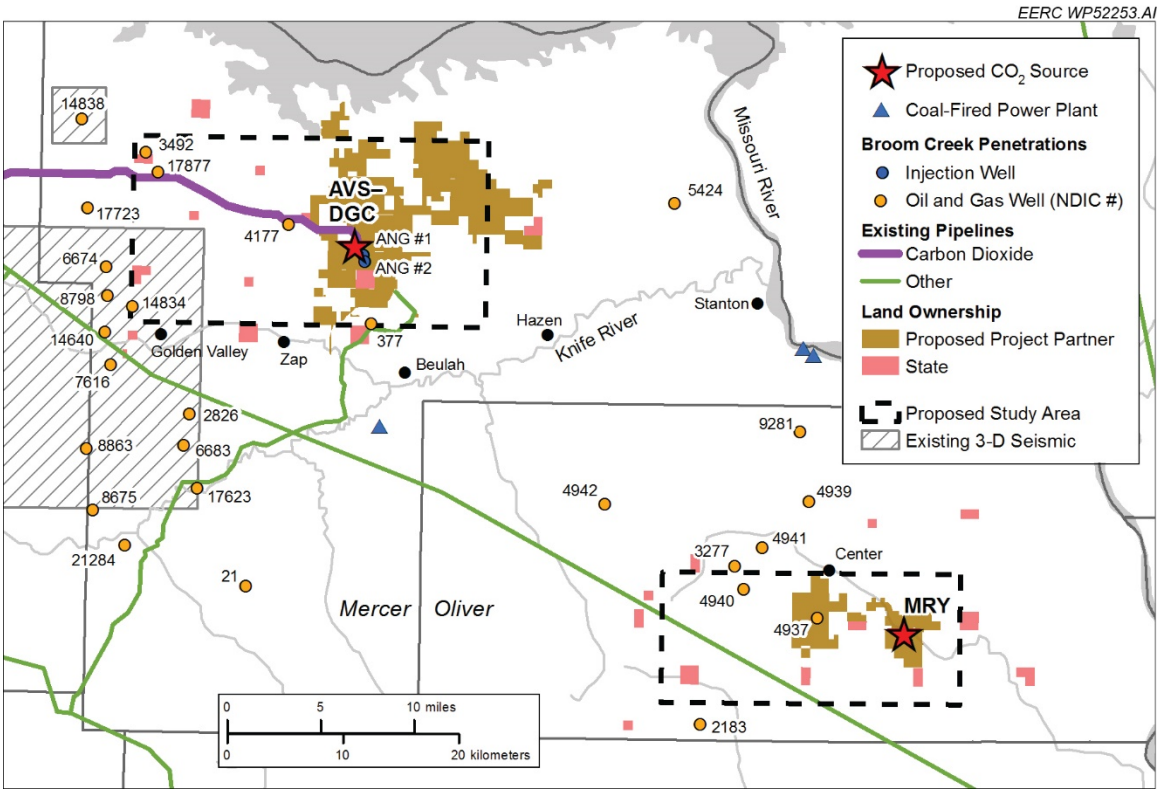

Figure 1. Map of the two targeted geologic storage study areas. The wells shown penetrate the Broom Creek Formation.

sample collection and characterization will provide significant information for use in geologic models to improve the determination of available CO_2 storage resource and establish the well-founded area of review (AOR) necessary for future permitting activities. Additional best practices that were refined through efforts of the PCOR Partnership and other members of the RCSP Program that will be applied in this project include those related to risk assessment and public outreach (U.S. Department of Energy, 2009). This current state of the science will be applied to address the various challenges associated with identifying and qualifying geologic storage sites capable of storing commercial-scale volumes of CO_2. Previous work through activities of the PCOR Partnership have contributed notably to broad characterization of geologic storage options for CO_2 in North Dakota, including studies on the Broom Creek Formation (Sorensen and others, 2009; Peck and others, 2014; Burton-Kelly and others, 2014). However, these earlier studies focused on regional to subregional areas of extent or examined the

opportunities presented by enhanced oil recovery (EOR). The results of efforts conducted in this project will provide the next logical steps in CO_2 storage research, namely, the development of a local-scale, qualified CO_2 storage site capable of handling commercial-scale injection volumes and addressing the associated nontechnical challenges presented by commercial-scale implementation. As such, this project will robustly determine the geologic suitability and social acceptability of a central North Dakota subsurface storage site.

Technical challenges of proving commercial-scale CO_2 storage capacity in central North Dakota will be addressed by engaging in detailed site characterization activities in the planned project areas (Figure 1). These activities will result in a substantial advance in the current state of knowledge of the subsurface in those areas. Two new characterization wells (a.k.a. stratigraphic test wells), one in each of the planned project areas, will be drilled, with acquisition of new core, fluid samples, and well log suites followed by detailed analysis. The first stratigraphic test well will be located approximately 10 miles west of the BEPC Antelope Valley Station (AVS)–DGC facilities and within the boundaries of an existing 3-D seismic survey, a portion of which will be purchased, reprocessed, and interpreted during the project. Incorporating the existing seismic data will allow the extrapolation of measurements and interpretations from well log and extensive geologic core data to provide increased understanding of the spatial distribution of geologic and petrophysical properties within the saline Broom Creek Formation. The second stratigraphic test well will be located just west of MRY on property owned by BNI Energy, a project partner. Using new and existing equipment, the EERC will acquire a 2-D seismic line through the test well to tie the geology observed at the well to an existing legacy seismic line, which will also be purchased and interpreted. As with the first stratigraphic test well, data obtained from the subsurface will be used to support modeling and simulation activities.

Planning both stratigraphic test wells in locations with preexisting seismic data sets will yield the greatest benefit/cost result and provide the most effective means of diminishing technical risks associated with geological uncertainty. The discrete geologic data sets from these activities will enable the development of comprehensive 3-D geocellular models with reduced uncertainty. These models will be

used in dynamic simulation activities to accurately determine an AOR associated with CO_2 and pressure plume development and distribution related to injection of 2 Mt of CO_2 over a 25-year time span.

During the project, development of a full understanding of the nontechnical challenges associated with large, complex research projects will be equally as important as addressing the technical challenges. These nontechnical challenges will be addressed through implementation of outreach activities for a variety of stakeholders (such as county representatives, regulatory groups, landowner groups, etc.). The project will also assess the challenges and costs associated with acquiring the necessary permits for a commercial-scale project and create a "site development plan" to addresses the various logistical challenges present with a multiorganizational commercial-scale carbon capture and storage (CCS) project.

By advancing the state of knowledge for conducting commercial-scale CCS projects in central North Dakota, the planned work will contribute directly to achieving the Lignite Research Council's (LRC's) goal of facilitating the expansion of opportunities to use North Dakota's lignite resources in an environmentally responsible manner in a carbon-constrained world. In addition, the planned project will help ensure that the lignite industry will continue to provide substantially to the economic well-being of North Dakota.

PROJECT DESCRIPTION

The EERC is a recent award recipient under DOE's CarbonSAFE Program. The successfully proposed project, entitled North Dakota Integrated Carbon Storage Complex Feasibility Study, will evaluate two promising potential geologic storage sites within the Broom Creek Formation, located adjacent to separate lignite-fired facilities in North Dakota. These efforts will determine the feasibility of developing a commercial-scale CO_2 geologic storage site capable of safely, permanently, and economically storing 50+ Mt of CO_2 in central North Dakota. These potential CO_2 geologic storage sites,
in combination with the motivated team, create an ideal synergistic scenario for promoting North Dakota's statewide vision for carbon management and supporting the continued use of North Dakota's lignite resources.

Objectives:

The primary objective of the project is to firmly establish the geologic, regulatory, and social suitability of a central North Dakota subsurface storage project in an effort to confirm the feasibility of developing a commercial-scale geologic storage site. Specifically, this project will provide a feasibility analysis for the development of a commercial-scale CO_2 geologic storage site capable of storing 50+ Mt of CO_2 in the Broom Creek Formation of central North Dakota safely, permanently, and economically.

Method:

The objectives of the project will be achieved through the seven tasks described below.

Task 1.0 – Project Management and Planning

This task includes the necessary activities to ensure coordination and planning of the project with all project sponsors. These activities include, but are not limited to, the monitoring and control of project scope, cost, schedule, and risk and the submission of project deliverables.

Task 2.0 – Storage Complex Characterization

This task conducts all the activity required to characterize the Broom Creek (reservoir unit) and overlying Opeche Formations (sealing unit) within the study areas of the proposed project. This includes updates to existing geologic and hydrogeologic evaluations based on new data from existing geologic resources, the collection of new data in the form of analysis of new core, subsurface fluid samples, and well logs and the acquisition and reprocessing of existing seismic surveys. Data acquired and analyzed during this task will be used in the development of Task 3.0 – Geologic Modeling and Simulation.

Subtask 2.1 – Existing Data Acquisition and Analysis

The geologic CO_2 storage complexes and point CO_2 emission sources in the North Dakota portion of the Williston Basin have been extensively characterized by the EERC through the PCOR Partnership regional characterization effort and other synergistic efforts within the EERC's oil and gas group (Glazewski and others, 2015). The saline Broom Creek Formation and its overlying sealing formation will be further evaluated to determine formation characteristics (such as porosity, permeability, injectivity, mineralogy,

fluid composition, geochemical conditions stratigraphy, caprock integrity, etc.) within the project study areas. Existing data, such as well logs, core analysis, and new geologic reports, will be screened for new or updated data not currently found in EERC databases. These data will be compiled and digitized (as necessary) in preparation for use in Task 3.0 activities. Additionally, data sets that may be purchased from private entities will be identified and assessed for potential inclusion in
Phase III activities.

This subtask will also acquire new or updated data sets that relate to land surface use and ownership within the study areas to identify pore space owners, geopolitical characterization, environmentally sensitive areas, and various rights-of-way (including pipelines). This information will be used to identify conflicts or opportunities for project development within the study areas and will be incorporated into Tasks 4.0–6.0.

Subtask 2.2 – Geologic Characterization Wells

This subtask will locate, permit, and drill two geologic characterization wells (stratigraphic test wells), one within each study area. These wells will be drilled to the Amsden Formation. Four-inch core will be taken from the cap rock of the Opeche Formation and the entirety of the Broom Creek Formation (approximately 350' of core per well), and a comprehensive logging suite will be collected from each well. The well-logging suite will be analyzed to understand the distribution of petrophysical and lithologic properties throughout the characterization wells for incorporation into Task 3.0. Once sampling and logging processes are completed, these wells will be plugged and abandoned according to procedures established by the North Dakota Industrial Commission (NDIC).

The precise location of these wells will be determined at the beginning of this project's period of performance. The characterization well drilled near the MRY facility will be located on property owned by BNI Energy. The characterization well near AVS–DGC will be located on private land within the boundaries of an existing 3-D seismic survey located ~10 miles to the west of AVS–DGC. Locating the characterization well here will allow for correlation of new log and core data with existing seismic data. Schlumberger Carbon Services has been retained to provide drilling, coring, and logging services.

Subtask 2.3 – Core Analysis/Testing

This subtask includes testing and analysis of core and fluid samples collected in Subtask 2.2. A suite of petrographic, petrophysical, geomechanical, and geochemical analyses will be performed on core samples to better understand factors that influence the long-term containment of CO_2, to aid in the calibration and correlation of well logs, and to improve the accuracy of geologic and simulation models. Specific analytical techniques (e.g., thin-section analysis, x-ray diffraction, x-ray fluorescence, scanning electron microscopy, steady-state relative permeability, helium porosimetry, and capillary pressure testing) will provide direct insight regarding the pore size distribution of the target reservoir and cap rock, potential for two-phase flow in a system dominated by high-salinity brine, zones of heterogeneity within the reservoir, and major and minor mineral phases. Geomechanical studies conducted in this task will focus on mechanical strength testing and will be interpreted to determine the maximum injection integrity of the cap rock. This work will be performed by the EERC's Applied Geology Laboratory.

Subtask 2.4 – Seismic Data Collection, Reprocessing, and Interpretation

This subtask covers the acquisition of both new and existing legacy reflection seismic data. New 2-D data will be acquired and processed by the EERC. Legacy 2-D and 3-D data are available and will be purchased from a data exchange company. The legacy 3-D data will be reprocessed with modern processing techniques by a seismic processing contractor. Seismic data will be interpreted at the EERC for the purpose of extending the point characterization data collected at the two test wells laterally for several miles to evaluate the structural and stratigraphic continuity of the target geologic horizons. The stratigraphic test well near the AVS–DGC location is planned to be drilled within the boundaries of an existing 3-D seismic survey that was acquired in the late 1990s, and about 10 square miles of this full-fold data from this survey will be purchased and reprocessed using modern processing techniques.

Near the MRY location, the EERC will acquire new 2-D reflection seismic lines to tie the second local test well with one or more legacy 2-D seismic lines that are available for purchase and which have been recently reprocessed. Up to 10 miles of new data is planned for acquisition using the EERC's

FairfieldNodal recording system and Gisco ESS850 source. In addition, about 12 miles of intersecting and recently reprocessed legacy 2-D seismic data will be acquired and interpreted to provide coverage in the form of a closed seismic loop to evaluate the MRY location.

Newly acquired and legacy seismic data will be interpreted to identify geologic structural and stratigraphic relationships and geologic heterogeneity within the study areas as well as provide correlation points with well logs and core data collected from the test wells. Data interpretations developed in this subtask will be provided to Task 3.0.

Task 3.0 – Geologic Modeling and Simulation

The geologic site characterization data (logs, core analysis, and seismic) will be integrated into geocellular models that account for the properties of the study areas, which comprise the injection horizon(s) and overlying sealing formation(s) that serve as barriers to prevent out-of-zone migration. The geologic models will provide the foundation for dynamic simulations of potential injection scenarios. Dynamic simulations are required to predict how CO_2 and its associated pressure plume would be distributed in the study areas and the effectiveness of the sealing formation at the site during the CCS time frame. Simulation results will provide key design and operational parameters for 1) the injection well and infrastructure, 2) a technical risk assessment, 3) AOR determination, 4) monitoring, verification, and accounting (MVA) planning, and 5) installation expenditures.

Subtask 3.1 – Geologic Modeling

The proposed study areas will be evaluated in this subtask through detailed reservoir-modeling efforts using Schlumberger Carbon Service's (Schlumberger's) Petrel geologic modeling software. The models will integrate the known and acquired geologic, structural, and fluid data of the study areas (for both the reservoir and confining zones) that were collected and analyzed in Task 2.0. These models may be used to assess seal effectiveness in CO_2 containment, CO_2 density under reservoir conditions, CO_2 storage resource, total and effective pore volume, both lateral and vertical geologic heterogeneity (as interpreted from 2-D and 3-D seismic data sets), and AOR (static, disregarding pressure response) for regions likely

to experience CO_2 saturation during injections resulting in 50+ million metric tons of CO_2. The geologic model will also provide the foundation for dynamic simulation of potential injection scenarios (Subtask 3.2).

Subtask 3.2 – Dynamic Simulation

This subtask will conduct dynamic simulations of the geologic model(s) to determine the potential distribution and extent of a 50-Mt CO_2 plume (2 Mt/yr for 25 years) based on the revised geologic assessments conducted during the previous tasks. Simulation models will be developed using Computer Modelling Group Ltd.'s (CMG's) GEM dynamic simulation module and history-matched to existing injection and/or production data where applicable. Injectivity of the storage complex will be assessed in order to confirm potential for injection of 50+ Mt of CO_2 at the project site(s) into the minimum number of injection wells. Development of the plume will be tracked throughout various simulations of the 25-year injection period to determine AOR and P_{10}, P_{50}, and P_{90} CO_2 plume extents through time. Simulations will also evaluate potential for conflicts with existing subsurface injection or production operations, although these are anticipated to be minimal based on current understanding of regional activities.

Task 4.0 – Public Outreach

The purpose of this task is to initiate public outreach to gain local public acceptance of a potential storage project. Areas of focus include stakeholder engagement activities, production and dissemination of informational materials, community outreach, implementation of a system to track engagement activities and acquire feedback, and ongoing assessment of progress. The various stakeholder groups targeted for engagement are anticipated to include local and regional officials, landowners and residents, and educators.

Public outreach activities are anticipated to include a detailed baseline assessment of stakeholder groups, their knowledge of and concerns regarding CCS, and their communication needs; outreach to stakeholder groups and the general public through individual contact, meetings, and open house formats; and the formation of an Outreach Advisory Group composed of representatives of the project partners and

key stakeholders to advise on the development of plans, activities, and products. Building on the outreach experience and materials from the PCOR Partnership Program, the project team will develop an outreach information tool kit (D3), a media kit, and project Web pages to be hosted on the EERC Web site. At a minimum, the outreach information tool kit is anticipated to contain project-focused Web pages; fact sheets; general audience presentation slides; general audience project posters; project-focused video shorts for use on the Internet and in presentations; and a media kit comprising general project information, graphics, press releases, frequently asked questions, and an animated video short depicting geologic CO_2 storage. As a culminating activity, the information and experience accumulated during the course of Phase II will be incorporated into an updated public outreach plan. Task activities will be coordinated with Task 6.0 in preparation for the development of future phases. DOE will have final approval of all materials prior to release.

Task 5.0 – Regulatory and Economic Analysis

This task will be conducted to evaluate the permitting requirements needed for future implementation of U.S. Environmental Protection Agency (EPA) underground injection control (UIC) Class VI injection wells. This evaluation will incorporate applicable local, state, and federal regulations and associated characterization activities in the study areas described by this task. The end result of this task will be a permitting plan that describes the process to obtain all necessary permits as they relate to the injection design for the storage complex. Site access agreements, pore space acquisition, and short-term project liability along with a cost model associated with pore space leasing or acquisition, bonding, permitting, and other related activities will be discussed in the plan.

This task will also examine more specific economic needs and the incentives in place to make the proposed scenarios economically feasible for the project partners. Local, state, and federal incentives will be evaluated for their potential contribution to offsetting project costs. These activities will form the basis for the development of a broad-scale business model.

Task 6.0 – Site Development Plan

This task will create a detailed plan for development of an injection site within the storage complex in Phase III of CarbonSAFE. This plan will be based upon the results of the other project tasks. It will include a site characterization plan for the potential injection site(s), a CO_2 management strategy for acquiring and transporting CO_2 to the injection site, and a risk assessment to identify project risks and provide mitigation strategies.

Subtask 6.1 – Site Characterization Plan

A detailed plan for a complete site characterization phase will be completed for characterizing and testing an injection site to reduce uncertainty in the subsurface and to address regulatory requirements specific to developing a Class VI qualified site and other stakeholder requirements. These data can define MVA needs and improve CO_2 storage performance forecasts. Characterization and testing, required for the approval of any Class VI wells and/or certification of associated CO_2 storage credits, may include collecting data related to the storage capacity of the chosen formation, determining the ability of the sealing formation to prevent migration from the storage complex, defining injection performance, and inspecting the mechanical integrity wellbore. The plan will thus provide for geologic core collection, downhole wellbore geophysical testing, and laboratory testing of both rock and fluid samples as deemed appropriate.

An assessment will also be made of local, state, and federal permits that may be needed for future installation of the injection site. This assessment will include data needs and potential time lines for acquisition of these permits in order to understand the potential permitting process needed for future CarbonSAFE phases.

Subtask 6.2 – CO_2 Management Strategy

This subtask will develop a management strategy for CO_2 that is focused on providing a reliable supply of coal-sourced CO_2 to future storage sites. The goal is to ensure that one or more reliable source(s) of CO_2 are accessible to the project. Sources that are both currently available and those which may be available

by the projected start of injection operations (in the 2025 time frame) will be considered. The most likely source option(s) will be identified. The CO_2 management strategy will account for known and expected variances for the selected source(s) in the variables known to impact gathering and transportation infrastructure, such as CO_2 quality, quantity, composition, pressure, temperature, and/or rate of delivery. The management strategy will show how these sources can be combined and delivered to the proposed injection site developed in Task 3.0. In addition, an evaluation of pipeline needs and how they could vary under a range of CO_2 source options will be performed. The CO_2 management strategy will minimize the costs of implementing capture and transport of the CO_2 from the selected source(s).

Subtask 6.3 – Risk Assessment and Mitigation Strategies

This subtask will conduct a risk assessment for the site development plan. The risk assessment process includes 1) risk identification, 2) risk analysis, 3) risk evaluation, and 4) risk treatment. Risk identification will be conducted to identify both technical and nontechnical risks that would prevent potential candidate storage reservoirs within the study areas from serving as commercial storage sites. Quantitative assessments of each identified risk will be made by assessing and scoring the probability that a risk event will occur and the impact that will result if it does occur. For technical risks, the project team will assess probability scores by incorporating the most current site characterization data and available modeling and simulation results. These assessments may be supplemented with outputs from National Risk Assessment Partnership (NRAP) tools (Task 7.0). Risk evaluation will include an uncertainty assessment to evaluate the variability in the risk probability and impact scores from the risk analysis. The uncertainty assessment will be used to develop representative most likely and maximum (worst-case) scores. Outliers, or unusually low or high scores, will trigger follow-up evaluation. The project team will define risk rank thresholds to identify high-ranking risks that warrant treatment or further analysis.

Once the risk assessment has been completed, a risk treatment strategy will be formulated. Risk treatment includes several different strategies for negative risks, including avoidance, transfer, mitigation, and acceptance, and positive risks, including exploitation, sharing, enhancing, and acceptance. A risk mitigation plan will be developed should any of these risks materialize. Communication is necessary

during every step of the risk assessment process to ensure stakeholders that the risks are being regularly monitored and effectively managed at all stages of the project.

Task 7.0 – NRAP Verification

As part of the risk analysis in Subtask 6.3, the EERC will use and validate select tool(s) developed through DOE's NRAP, where "validation" means comparing outputs from the NRAP tools against commercial software packages. The EERC will use a FMEA (failure modes and effects analysis) approach to guide risk identification by conceptualizing the study areas as a system of components (e.g., reservoir, seals, wells, groundwater aquifers, CO_2 supply, etc.). In the risk analysis (Subtask 6.3), subject matter experts will assess probability scores by incorporating the most current site characterization data and available modeling and simulation results. This analysis will be supplemented with NRAP tools, which are well-aligned with the FMEA approach.

The EERC has identified the Reservoir Evaluation Visualization (REV), Natural Seal ROM (NSealR), and Wellbore Leakage Analysis Tool (WLAT) as likely NRAP tools for validation with the data generated in the proposed work. These tools will provide assessments of the storage complex, which are similar to the characterization, modeling, and simulation assessments being conducted to meet the Phase II objectives. Depending on the project-specific needs, additional NRAP tools may be used and validated. These include other models within the Integrated Assessment Model (IAM) or tools from DOE's Carbon Storage Program.

Anticipated Results:

Previous work through activities of the PCOR Partnership have contributed notably to broad characterization of geologic storage options for CO_2 in North Dakota, including studies on the Broom Creek Formation (Sorensen and others, 2009; Peck and others, 2014). However, these earlier studies focused on regional to subregional areas of extent or examined the opportunities presented by EOR. The results of the efforts conducted in this project will provide the next logical steps in CO_2 storage research. Namely, the development of a local-scale, qualified CO_2 storage site capable of handling commercial-

scale injection volumes and addressing the associated nontechnical challenges presented by commercial-scale implementation. As such, this project will determine the geologic suitability and social acceptability of a central North Dakota subsurface storage site capable of cost-effectively storing 50+ Mt of CO_2.

The subsurface horizon of interest in the planned project is the Broom Creek Formation, a deep sandstone formation saturated with saline water underlying a large portion of central and southwestern North Dakota. Multiple reports (Fischer and others, 2008; Sorensen and others, 2009; Peck and others, 2014) have discussed the ability of the Broom Creek Formation to serve as a world-class CO_2 storage horizon. This preliminary assessment is founded mainly on the examination of numerous publicly available geophysical well logs and previous testing of only three geologic cores (one of which no longer exists). This project will double the number of existing Broom Creek cores and provide the first comprehensive geologic data for the Broom Creek Formation in the lignite-fired power plant region of North Dakota. This information will significantly improve the technical understanding of the geologic storage formation present in the study areas. It will also verify assumptions made about the storage potential of the study areas in prior regional assessments and dramatically reduce uncertainties associated with the prior studies.

Two new stratigraphic test wells, one in each of the planned project areas, will be drilled through the Broom Creek Formation (approximately 5800 feet deep). Characterization of these wells will include acquisition of new core, fluid samples, and well log suites. Detailed laboratory analysis of rock core samples will provide petrophysical and petrographic properties that will be correlated to the newly acquired well logs. The first stratigraphic test well will be located approximately 10 miles west of the AVS–DGC facilities, and within the boundaries of an existing 3-D seismic survey, a portion of which will be purchased, reprocessed, and interpreted as part of the project. Incorporating the existing seismic data will allow the extrapolation of measurements and interpretations from well log and extensive geologic core data to provide increased understanding of the spatial distribution of geologic and petrophysical properties within the Broom Creek Formation. The discrete geologic data sets from these activities will enable the development of comprehensive 3-D geocellular models with reduced uncertainty. These

models will be used in dynamic simulation activities to accurately determine the AOR associated with CO_2 and pressure plume development. Thus the acquisition of geologic data confirming the feasibility of establishing a qualified large-scale CO_2 storage site will reduce the technical uncertainty with respect to the potential implementation of a commercial-scale operation.

Developing a full understanding of the nontechnical challenges associated with large, complex research projects is equally as important as addressing the technical challenges. This project will establish a thorough understanding of these challenges and address them through implementation of outreach activities for a variety of stakeholders (such as county representatives, regulatory groups, landowner groups, etc.). In addition, this project will result in an assessment of the challenges and costs associated with acquiring the necessary permits for a commercial-scale project and preparation of a site development plan which will address the various logistical challenges present with a multiorganizational commercial-scale CCS project. Every CCS project site offers unique opportunities and challenges, and the planned project will induce advances in knowledge, technology, and techniques to address these opportunities and advance the knowledge base for CCS in North Dakota. Each of the project activities will advance the state of readiness for conducting commercial-scale CCS projects in North Dakota and provide lessons learned to each of these processes to help ensure the successful deployment of future commercial-scale projects.

Facilities and Resources:

The EERC has a technical team with extensive research and operational experience. The multidisciplinary team is integrated with respect to geologic characterization, geologic modeling, predictive reservoir simulation, monitoring operations, and risk assessment related to CO_2 storage. In addition, the EERC has expertise in analysis of large, diverse data sets. The EERC is committed to providing the necessary personnel resources to cost-effectively conduct the activities outlined in this proposal.

The North Dakota portion of the Williston Basin has a history of hydrocarbon production dating back to 1951. Because of a long history of production, extensive oil and gas data sets are available. Most notably, data sets from over 30,000 wells are publicly available from NDIC, which the EERC regularly

accesses and uses for CO_2-, oil-, and gas-related projects. These data sets consist of both spatial and tabular databases. Other available data include seismic surveys (2-D and 3-D), geophysical well logs, core data, water quality data, groundwater well locations, and water salinity.

The EERC has extensive modeling and simulation capabilities, including multiple high-end workstation computers and a dedicated high-performance parallel computing cluster. The cluster comprises eight computing nodes consisting of 232 total cores available for modeling and simulation usage. All of the nodes/threads share a network-based power vault with a massive file server. Additionally, the project team has access to industry-level geologic modeling and simulation software, database capabilities for managing data that will be collected and generated during the project, and GIS (geographic information system) software for creating high-quality maps and images of results. Additional details on EERC facilities, resources, and equipment are described in Appendix A.

Finally, the EERC has also obtained letters of support from the field site owners, a private landowner, and BNI Energy that will allow necessary access for drilling of the two stratigraphic test wells. These letters of support are provided in Appendix B.

Techniques to Be Used, Their Availability and Capability:

Techniques to be employed in this project are detailed in the methods section above. All techniques are anticipated to be available throughout the duration of the project.

Environmental and Economic Impacts while Project Is Under Way:

Environmental impacts will be relatively minimal during execution of this project. Two new stratigraphic test wells, one in each of the planned project areas, will be drilled, with acquisition of new core, fluid samples, and well log suites followed by detailed analysis. Before drilling can begin, all necessary local, state, and federal environmental review and permitting processes will be complete. The first stratigraphic test well will be located on private land approximately 10 miles west of the AVS–DGC facilities. The second stratigraphic test well will be located just west of the MRY Station on property owned by BNI Energy, a project partner. Each well will require approximately 2–3 acres of land, and take 2 weeks to

drill, core, and log. Upon completion of the data collection activities, the wells will be plugged and abandoned following rules and procedures defined by NDIC and the land restored to its original condition. In addition to the new wells, the EERC will acquire a 2-D seismic line that will intersect the second test well to tie the geology observed at the well to an existing legacy seismic line. The seismic acquisition activity will use a stationary, trailer-mounted energy source. Seismic receiver components will be emplaced by hand. Lab-scale testing of the core at the EERC will be in a controlled environment, with very small amounts of material used that will be disposed of according to standard University of North Dakota (UND) Environmental Health and Safety practices once the testing is complete. Economic impacts will also be minimal and will not have appreciable effects on any of the organizations participating, with the exception of regular employment economic effects for those working on the project.

Ultimate Technological and Economic Impacts:

A vibrant lignite industry is very important to North Dakota. The activities conducted in this project will support existing and future opportunities for adding value to carbon management by greatly increasing confidence in the quantity and security of CO_2 storage resources available to North Dakota lignite generators and consumers to support CCS investments. The project will also demonstrate local applicability of emerging best practices for storage risk assessment, injection and monitoring, and building capacity among supporting industry partners for CCS deployment in the context of local storage opportunities and nearby communities. Outcomes of this project will enable the use of North Dakota's lignite resources in any future carbon-constrained policy environments and assist in positioning North Dakota's lignite-derived energy to be competitive against other low-carbon technologies. In addition, this project will contribute to a reduction in future costs and timescales of CCS and storage deployment through increased confidence of local stakeholders, including regulators and local communities.

In summary, the project will provide partners with critical, previously unavailable data on the technical, economic, and societal feasibility of capture, compression, and geologic storage of CO_2 from a lignite-fired power plant in central North Dakota.

Why the Project Is Needed:

Regional assessments have shown substantial potential for CO_2 storage in North Dakota (Sorensen and others, 2009; Peck and others, 2014; Glazewski and others, 2015), but site-specific recommendations that build upon this work are still limited in their precision. Efforts are needed to fill the gaps in knowledge of site-specific subsurface geologic characterization to overcome these challenges. This work seeks to address these remaining key knowledge gaps and provide a road map for future development of a commercial CCS project, unique among existing research in both its scale and scope. The data collected from these wells and seismic data will serve to significantly improve the technical understanding of the geologic storage formation present in the study areas and verify assumptions made about the storage potential of the study areas in prior regional assessments.

Until recently, the necessary combination of economic incentives, regulatory requirements, and technical understanding for geologic CO_2 storage (via CO_2 EOR or saline storage) has not been in place. Circumstances now exist to pursue a large-scale, integrated CCS effort because of recent tax incentive programs and progressive North Dakota pore space ownership and long-term liability laws. In addition, there is a growing demand for low-carbon energy sources. North Dakota is at the forefront of energy development and production, and the North Dakota energy industry is motivated to provide solutions to challenges presented by that demand. The state continues to investigate long-term strategies that incorporate all energy resources—traditional and emerging—to meet the nation's growing energy demand in an environmentally responsible manner. This project is needed now and will lead to expanded opportunities for the state's coal and other energy industries. Ideal synergistic scenarios, involving willing partners, an existing CO_2 pipeline, a promising geologic storage formation, readily available captured CO_2, and progressive North Dakota pore space ownership and long-term liability laws, will be

investigated as a means to meet these challenges and ensure the continued use, and expansion of North Dakota's lignite resources.

STANDARDS OF SUCCESS

Success will be demonstrated in the establishment of the geologic, regulatory, and social feasibility of developing a commercial-scale geologic storage site for captured CO_2 in central North Dakota. Participation in outreach activities by members of the project team organizations and involvement by business and citizens in the Mercer and Oliver County areas will be a hallmark of success with respect to stakeholder engagement to gauge public acceptance of a potential commercial-scale CO_2 storage project. Collection and analysis of the new geologic core and geophysical logs from the two planned stratigraphic test wells and integration of these data to new and existing seismic data will mark a major success in understanding CO_2 storage and movement in deep subsurface with respect to the Broom Creek Formation.

BACKGROUND/QUALIFICATIONS

Several public and private entities have pledged financial support for the planned EERC-led effort. These major participants include BEPC, ALLETE Clean Energy (ACE), BNI Energy, North American Coal, MPC, Prairie Public Broadcasting, CMG, and Schlumberger. These partners will provide critical support in the form of financial backing, engineering evaluations, site access, outreach collaboration, operations data, risk assessment and evaluation, and software access and support needed to achieve the project objectives.

Lead Organization – EERC

The EERC has broad experience with leading multidisciplinary teams comprising private and public entities. Foremost among this experience is the PCOR Partnership, which is one of seven regional partnerships awarded in 2003 by the DOE National Energy Technology Laboratory (NETL) to determine

the best approaches to geologic storage and apply technologies to safely and permanently demonstrate the storage of CO_2. The PCOR Partnership region covers an area of over 1.4 million square miles in the central interior of North America and includes all or part of nine U.S. states and four Canadian provinces. Currently in the tenth year of a demonstration phase, the PCOR Partnership is testing the validity of different characterization, modeling and simulation, risk assessment, and monitoring techniques and technologies to advance the science of CO_2 storage in geologic formations. Since its inception, the PCOR Partnership has brought together more than 100 public and private sector stakeholders with vast expertise in power generation, energy exploration and production, geology, engineering, the environment, agriculture, forestry, and economics. Partners are the backbone of the PCOR Partnership and provide data, guidance, financial resources, and practical experience with CCS, all necessary to undertake commercial-scale CO_2 storage projects, regional characterization efforts, and large-scale CO_2 storage project feasibility studies.

Notable completed efforts under the PCOR Partnership Program include a best practices manual on a feasibility study surrounding the potential to injection over 2 Mt of CO_2 a year near Spectra Energy's Fort Nelson Gas-Processing Plant, the completion of an updated Regional Technology Implementation Plan surrounding Apache Canada's Zama acid gas EOR and CO_2 storage project, and a binational effort between the United States and Canada to characterize the lowermost saline system (Basal Cambrian) in the Williston and Alberta Basins. In addition to the completed efforts, there are several ongoing efforts, including injection at the Bell Creek project and injection at the Aquistore project.

At the Bell Creek oil field in southeastern Montana, the PCOR Partnership is working with Denbury Onshore LLC (Denbury) to study CO_2 storage associated with commercial CO_2 EOR. Denbury is carrying out injection and production operations, with the PCOR Partnership providing support for site characterization, modeling and simulation, integrated risk assessment, and MVA of the injected CO_2. As of June 2016, 3.2 million metric tons of CO_2 has been stored since injection operations began at the Bell Creek Field in May 2013.

The Aquistore project, managed by the Petroleum Technology Research Centre (PTRC), serves as a saline storage site for CO_2 captured at SaskPower's Boundary Dam, the world's first commercial-scale postcombustion coal-fired CCS facility. The PCOR Partnership is working with PTRC on site characterization, risk assessment, public outreach, and MVA activities at the Aquistore site. Since the start of injection in April 2015, the PCOR Partnership has been conducting near-real-time history-matching and predictive simulation activities using daily injection data. This work is aiding in the deployment of MVA at the Aquistore site.

The EERC-led PCOR Partnership has implemented an outreach program featuring project-focused outreach as well as broadly focused general outreach on CCS. Project-related outreach activities range from project pages on the PCOR Partnership public Web site to participation on project outreach advisory panels, to managing project-based outreach, to custom project-focused outreach materials, to interaction with local stakeholders. Regional outreach has been accomplished through original documentaries broadcast on public television and participation in educator workshops, library conferences, and decision-maker forums. All outreach is tracked, and both project and general outreach are supported by a public Web site, a source of basic CCS information and access to a spectrum of audience-appropriate original outreach materials, including streaming video and DVDs, fact sheets, a regional atlas, and public information posters. The EERC's PCOR Partnership outreach team has shared lessons learned within the RSCP Program through participation in its Outreach Working Group and with the greater outreach community through the preparation of outreach best practices manuals.

Project Partners

The project partners represent vested stakeholders in coal production and conversion in central North Dakota. Each partner will contribute to several portions of the scope of work as follows: 1) participate in risk assessment and evaluation workshop(s); 2) participate in planning, developing, reviewing, and in some instances distributing various forms of outreach materials; 3) provide input and feedback on the various regulatory statutes that may apply to central North Dakota for full implementation of the

CarbonSAFE program; and 4) provide input and feedback on current and potential financial and business model development for implementation of commercial-scale CCS in central North Dakota. These elements are critical to the success of the scope of work.

Letters of commitment from key North Dakota entities for technical and financial support for the project have been provided by BEPC, ACE, BNI Energy, North American Coal, MPC, Prairie Public Broadcasting, Schlumberger, and CMG.

Letters of support have also been provided by a variety of local, state, and federal agencies and representatives which also represent the broader project team. These entities include NDIC, the North Dakota Association of Oil and Gas Producing Counties, the North Dakota EmPower Commission, U.S. Senators John Hoeven and Heidi Heitkamp, U.S. Representative Kevin Cramer, and former North Dakota Governor Jack Dalrymple. Letters of commitment/support are provided in Appendix B.

MPC is a regional generation and transmission cooperative that supplies power to 11 member–owner distribution cooperatives across 34,500 square miles of eastern North Dakota and northwestern Minnesota. MPC brings the expertise and insight into the regulatory acceptance of the coal industry along with financial support and cost-share contributions.

ACE was established to help transform the nation's energy landscape by creating energy solutions by way of wind, solar, biomass, hydro, natural gas, shale resources, clean coal technology, and other emerging energy innovations through acquisition or development of capital projects. ACE, BNI Energy, and MPC have launched "Project Tundra" to develop an integrated carbon capture, transportation, utilization, and storage system to provide CO_2 to the oil fields of western North Dakota while reducing air emissions of CO_2 and ensuring continued use of the reliable and affordable generating facilities in the state (see Project State of Development). Contributions from ACE will include monetary backing for this project.

BEPC is a wholesale electric generation and transmission cooperative in North Dakota that provides power to over 540,000 square miles across nine states in the United States. BEPC has unique and extensive business experience within the energy industry and will provide perspective to the North

Dakota CCS effort while also providing financial contributions. BEPC will also bring a CO_2 source through its AVS and DGC plants and an existing transport mechanism with its existing CO_2 pipeline and support infrastructure.

BNI Energy, a subsidiary of ALLETE, Inc., owns and operates the Center Mine near Center, North Dakota. With corporate headquarters in Bismarck, North Dakota, the BNI Energy team comprises skilled and experienced operators and professionals. BNI Energy has agreed to contribute financial backing and to waive fees for land access and assist with site preparation and reclamation to drill a stratigraphic test well.

North American Coal is one of the United States' largest miners of lignite coal and among the largest coal producers in the country. North American Coal mines 15 million tons of lignite each year at the Freedom Mine in Mercer County, North Dakota, which supplies DGC and AVS. North American Coal brings cost share and vast expertise and insight into the regulatory aspects of the lignite industry to this project.

Schlumberger is a leading service provider for the oil and gas industry and has been a pioneer in addressing the challenges of safely, reliably, and efficiently storing CO_2 in the subsurface through its adaptation of proven technologies. Schlumberger will provide technical and operational assistance with drilling the two planned stratigraphic test wells and has committed to provide software licenses and support to conduct the geocellular modeling activities.

CMG is the world's leading independent supplier of reservoir simulation technologies. CMG's focus is on providing the best modeling and simulation software for subsurface characterization to address the challenging questions associated with the long-term fate of CO_2 and other fluids injected into the reservoir. CMG will provide in-kind cost share in the form of reservoir simulation software license tools and technical support.

Prairie Public Broadcasting provides national and regional television and radio programming that educates all ages. Prairie Public Broadcasting will contribute to the project by providing video equipment,

technology, and staff to create videos and documentaries of the project to educate and inspire the people of the region.

EERC Technical Capabilities:

Mr. Wesley Peck, Principal Geologist and Geosciences Group Lead at the EERC, will handle the project management, planning, and reporting activities. In addition to having served as the principal investigator (PI)/project manager on several DOE projects at the EERC, Mr. Peck serves as the task lead for the regional characterization effort of the PCOR Partnership Program. He is a coauthor of a PCOR Partnership topical report that examined the potential for geologic storage of CO_2 in the Lower Cretaceous system of the Williston Basin, which includes the formation that will serve as the test reservoir for the recently awarded BEST (brine extraction and storage test) project. As such, Mr. Peck is very familiar with the geology of the key formations to be investigated in the project and will provide guidance with respect to their characterization.

Mr. Ryan Klapperich, EERC Senior Hydrogeologist responsible for overseeing all aspects of the storage site characterization effort. Mr. Klapperich has expertise in CO_2 EOR and storage, including geologic site characterization, monitoring program assessments, design and implementation of near-surface monitoring programs, and interpretation of monitoring data. Mr. Klapperich is actively involved in many site characterization and CO_2-monitoring activities at the EERC. Mr. Klapperich has served as the Co-PI on a project principally funded by the IEA Greenhouse Gas R&D Programme (IEAGHG) focused on understanding the use of active reservoir management (ARM) schemes to enhance CO_2 storage and reduce MVA costs. Mr. Klapperich currently serves as the Co-PI on the recently awarded BEST project which will demonstrate the use of ARM techniques to improve reservoir storage potential in saline formations with CO_2 storage potential. Mr. Klapperich also currently serves as the task lead for the PCOR Partnership's Water Working Group, a working group comprising members of DOE's RCSP Program focused on developing an understanding and solutions for issues at the nexus of CCS and water.

Mr. Lonny Jacobson, EERC Senior Operations Specialist will be responsible for well-drilling activities and all data-processing and closeout activities. Mr. Steven Smith, EERC Senior Geologist, will assist with core analysis and testing, and Mr. Shaughn Burnison, EERC Principal Geophysicist and Geophysics Team Lead, will be responsible for seismic data processing.

Mr. Nicholas Bosshart, EERC Senior Geologist and Geomodeling Team Lead, will be responsible for geologic modeling and simulation. Mr. Bosshart has expertise and experience in well log, core, and thin-section petrophysical analysis; geologic characterization and data management; geostatistical applications; geocellular reservoir modeling; EOR utilizing CO_2; and geologic storage of CO_2. He is currently involved in multiple DOE-funded projects involving modeling and numerical simulation efforts aimed at increasing our understanding of CO_2 storage, residual oil zones, and CO_2 EOR; CO_2 storage efficiency, brine extraction for reservoir pressure management, risks associated with CO_2 storage, and management of these risks through existing and novel MVA activities; and determining the long-term fate of injected CO_2. He is a member of the American Association of Petroleum Geologists, the European Association of Geoscientists, and the Geological Society of America.

Mr. Lawrence Pekot, EERC Principal Engineer and Reservoir Engineering Group Lead, will oversee dynamic simulation. Mr. Pekot has 15 years of experience investigating CO_2 injection and storage projects and has led numerous evaluations and field demonstrations worldwide. Additionally, he has considerable experience with the natural gas storage industry and is, therefore, intimately knowledgeable with issues related to repeated injection and extraction operations, evaluation of well testing, well interference effects, injectivity, and deliverability.

Mr. Daniel Daly, EERC Senior Geologist/Public Outreach Specialist and Outreach Team Lead, who will be responsible for implementing and refining the public outreach plan. Mr. Daly serves as the manager for the Outreach and Education task under the PCOR Partnership (2003–present; clients: DOE and more than 100 government and industry stakeholders in the United States and Canada). Previously, he served in the following capacities: coordinator of the Red River Valley Clean Cities Coalition; project manager, Red River Geoscience Education Pilot Project; task manager, Red River Environmental

Information Network; member of the management team for the Cooperative Agreement, providing technical support for the development of innovative technologies to aid in nuclear complex cleanup under the DOE Environmental Management Program; task manager for a national-level assessment of waste generation and shallow subsurface environmental issues related to gas industry exploration and production; and tracking and assessment of government policy and regulatory actions in support of strategic planning for the EERC.

Mr. Barry Botnen, EERC Hydrogeologist, will be responsible for activities related to regulatory analysis. He currently supports multiple activities for the PCOR Partnership. Most recently, Mr. Botnen has been working to develop and implement MVA concepts for large-scale (>1 million tons per year) CO_2 storage and EOR operations. Mr. Botnen also served as the task lead for the Terrestrial Field Validation Test portion of the PCOR Partnership. Mr. Botnen has over 20 years of experience in CO_2 sequestration/storage, contaminated site assessment, contaminant release investigation, remedial design/action, wetlands identification/delineation, biota studies, and the stewardship of contaminated nuclear sites.

Mr. James Sorensen, EERC Principal Geologist, will be responsible for the overall site development plan. He has served as the PI/project manager on several projects at the EERC, including projects funded by DOE, IEAGHG, and private industry. Mr. Sorensen has managed the multimillion-dollar, multiyear, multidisciplinary feasibility study of the Fort Nelson CO_2 Capture and Storage Project, conducted as part of the PCOR Partnership Program. In addition, Mr. Sorensen is the primary author of a PCOR Partnership topical report that examined the potential for geologic storage of CO_2 in the Lower Cretaceous system of the Williston Basin, which includes the formation that will serve as the test reservoir for the recently awarded BEST project. Mr. Sorensen is also a coauthor on a PCOR Partnership topical report on the geology of the Broom Creek Formation. As such, Mr. Sorensen is very familiar with the geology of the key formations that will be investigated in the planned project and will provide guidance with respect to their characterization.

Dr. José Torres, EERC Senior Reservoir Engineer, will be responsible for activities related to verifying one or more NRAP tools. Dr. Torres has experience and expertise in varying aspects of reservoir engineering, such as reservoir simulation, production mechanisms and EOR for unconventional reservoirs, fluid flow in porous media, and thermodynamics of reservoir fluids. Dr. Torres's work focuses on resolving the advanced challenges of unconventional reservoirs related to production mechanisms and CO_2 EOR in tight reservoir rocks, CO_2 storage, high-volume brine disposal, and advanced reservoir-monitoring techniques.

Mr. Charles Gorecki, EERC Director of Subsurface R&D, will serve as a project advisor and provide senior oversight and will ensure that Mr. Peck has the resources necessary to complete the scope of work in a timely and cost-effective manner. He will also coordinate a final technical review of all work products generated as part of the project. Mr. Gorecki has served as the PI/project manager on several projects at the EERC, including projects funded by DOE, IEAGHG, and private industry. Currently, Mr. Gorecki manages PCOR Partnership Program. In addition, Mr. Gorecki oversees large projects as the Director of Subsurface R&D at the EERC, ensuring that PIs have the staff and resources necessary to successfully complete project objectives. Mr. Gorecki is very familiar with DOE's Carbon Storage Program and has demonstrated the ability to effectively manage multiple large-scale, multiyear projects.

Resumes of key personnel are in Appendix C.

VALUE TO NORTH DAKOTA

Using 2015 data, a recently completed study by the Department of Agribusiness and Applied Economics at North Dakota State University shows the lignite industry continues to provide about $3.4 billion to the state's economy every year and $104 million in taxes to the state. The continued use and growth of lignite use in North Dakota will require innovative and environmentally sound practices that explore all options that manage captured CO_2. This project will assist the LRC, its member organizations, and the state of North Dakota in planning for future development of CO_2 capture and storage in deep saline formations. The successful completion of this project will also support other industries (e.g, ethanol producers) that

may want, or be required by future regulation, to manage their CO_2. Results of this project will directly facilitate the expansion of opportunities to use North Dakota's lignite resources in an environmentally responsible manner in a carbon-constrained world, and in doing so, will ensure that the lignite industry will continue to provide substantially to the economic well-being of North Dakota. In addition, any mechanism that helps the state's energy industry manage its CO_2 will allow those industries to take advantage of markets that are looking for more environmentally conscious energy options.

MANAGEMENT

The EERC manages over 200 contracts a year, with more than 1330 clients in 52 countries. Mr. Wes Peck, Principal Geologist and Geosciences Group Lead, will oversee the entire project. Internal meetings will be scheduled regularly with project staff and advisors to ensure that the project is being conducted using acceptable scientific methodologies and practices in accordance with the project plan (budget, schedule, deliverables, and milestones) and is meeting quality objectives. Partners will be kept abreast of project progress and coordinate activities as necessary for the execution of a successful project. The EERC will be responsible for timely submission of all project deliverables. In addition, milestones have been developed to ensure timely progress of the project. Milestones are presented in Table 1.

Table 1. Project Milestones

Task/Subtask	Milestone (M) Title	Planned Completion Month
2.2	M1 – Initiation of Well Drilling	6
2.4	M2 – Completion of Seismic Reprocessing	6
6.3	M3 – Risk Assessment Workshop Scheduled	9
3.2	M4 – Identification of Inputs for NRAP Model(s)	14
3.1	M5 – Completion of Geologic Modeling	15
6.3	M6 – Updated Risk Assessment Workshop Scheduled	18

The core project team, shown in Figure 2, comprises researchers from the EERC, with in-kind and cash cost-share support provided by NDIC's LRC, BEPC, ACE, BNI Energy, North American Coal, Minnkota, Schlumberger, CMG, and Prairie Public Broadcasting.

Quarterly progress reports will be submitted 1 month after the end of each calendar year. A final report will be submitted to all project sponsors at the completion of the 2 years.

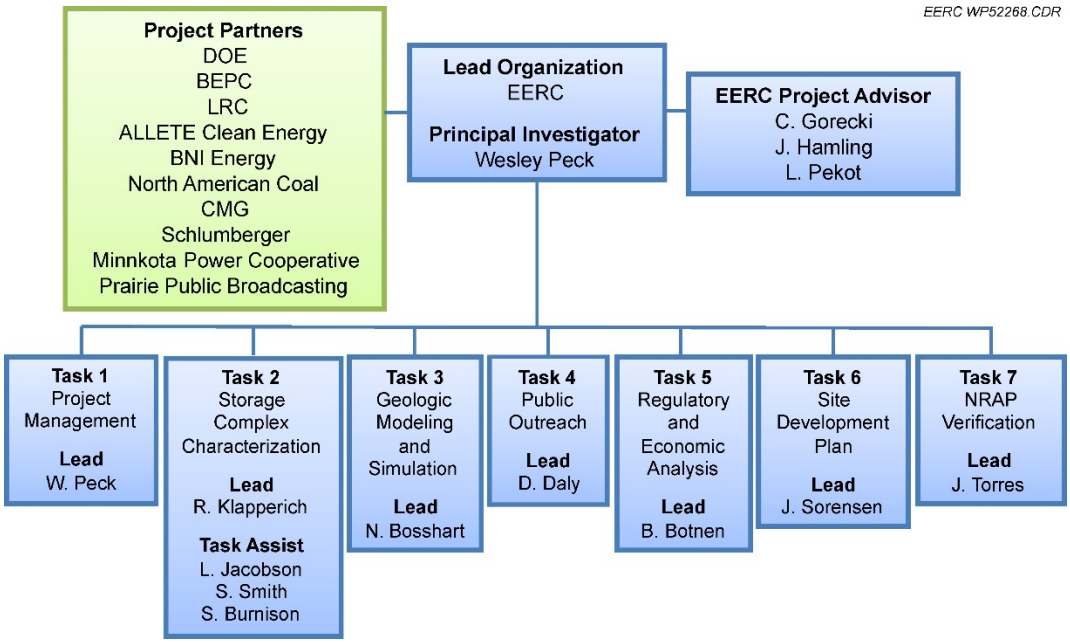

Figure 2. Project organization chart.

TIMETABLE

The estimated period of performance for the proposed work is 2 years. The EERC is currently under contract negotiations with DOE and other project sponsors. Once an agreement is fully executed with DOE, the EERC may make the determination to initiate the project. It is estimated that it will be not later than the end of February 2017.

The project timetable is presented in Figure 3.

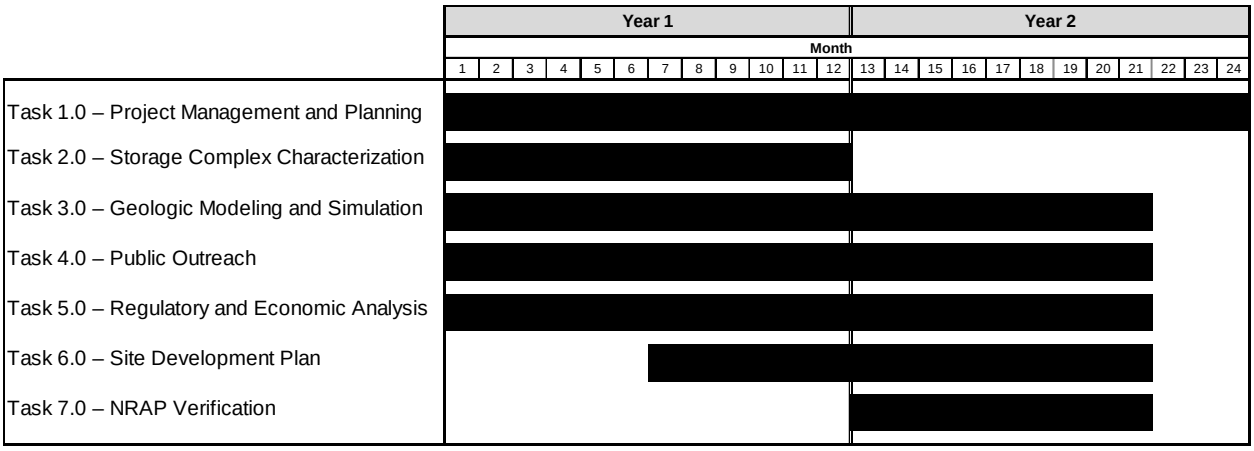

Figure 3. Project Timetable.

BUDGET

The total estimated cost of the proposed project is $13,857,978. Budget details can be found in Table 2 and in the budget justification (Appendix D). LRC is asked to provide $1,500,000 for this project, and the remaining $12,357,978 will be provided by DOE and industry partners. The requested LRC funding is necessary to complete the scope of work as proposed. Should full funding from LRC not be available, the scope of work will be notably impacted.

Table 2. Budget Details

CATEGORY	PROJECT TOTAL	LRC SHARE	COST SHARE
Total Labor	$3,243,525	$589,692	$2,653,833
Travel	$208,662	$ –	$208,662
Equipment > $5000	$90,542	$ –	$90,542
Supplies	$323,601	$254,750	$68,851
Subcontractor – Schlumberger	$4,406,620	$ –	$4,406,620
Subcontractor – Prairie Public Broadcasting	$15,500	$ –	$15,500
Consultant – CETER Group	$60,000	$ –	$60,000
Consultant – Outreach	$30,500	$ –	$30,500
Communications	$16,200	$386	$15,814
Printing & Duplicating	$15,550	$216	$15,334
Food	$7,100	$ –	$7,100
Fee – Landowner Access	$25,000	$25,000	$ –
Fee – Seismic Reprocessing	$32,500	$32,500	$ –
Laboratory Fees & Services			
Natural Materials Analytical Research Lab	$28,254	$28,254	$ –
Graphics Service	$71,652	$1,880	$69,772
Shop & Operations	$3,357	$ –	$3,357
Research Information Service	$6,192	$ –	$6,192
Outside Lab	$64,000	$64,000	$ –
Total Other Direct Costs	$5,405,230	$406,986	$4,998,244
Total Direct Costs	$8,648,755	$996,678	$7,652,077
Facilities & Admin. Rate – % of MTDC	$2,138,867	$503,322	$1,635,545
Total Cash Requested – U.S. Dollars	$10,787,622	$1,500,000	$9,287,622
In-Kind Cost Share	$3,070,356	$ –	$3,070,356
Total Project Costs – U.S. Dollars	$13,857,978	$1,500,000	$12,357,978

MATCHING FUNDS

The cost share totaling $12,357,978 will be provided in a combination of cash and in-kind by DOE, BEPC, Minnkota, ACE, BNI Energy, North American Coal, Sclumberger, CMG, and Prairie Public Broadcasting as show in Table 3 below. In-kind contributions from BEPC, BNI Energy, ACE, Minnkota, and North American Coal will be in the form of technical support; Schlumberger and CMG contributions will be in the form of software licenses for modeling and simulation activities. Prairie Public Broadcasting contributions will be in the form of services for public outreach activities.

Table 3. Matching Funds

Funding Source	Type	Total
DOE	Cash	$8,787,622
BEPC	Cash	$300,000
BEPC	In-kind	$200,000
ACE, BNI, Minnkota	Cash	$200,000
ACE, BNI, Minnkota	In-kind	$100,000
North American Coal	In-kind	$100,000
Schlumberger	In-kind	$2,308,096
CMG	In-kind	$338,760
Prairie Public Broadcasting	In-kind	$23,500
Total		**$12,357,978**

TAX LIABILITY

The EERC, a department within UND, is a state-controlled institution of higher education and is not a taxable entity; therefore, it has no tax liability.

CONFIDENTIAL INFORMATION

This proposal contains no confidential information.

APPENDIX A

FACILITIES, RESOURCES, AND EQUIPMENT

FACILITIES

Energy & Environmental Research Center (EERC)

Originally founded in 1951 as a government research facility, the Energy & Environmental Research Center (EERC) was privatized in 1983 and currently occupies a research complex consisting of 254,000 square feet of offices, technology demonstration facilities, and laboratories. The engineering and scientific research staff members are equipped with state-of-the-art analytical, modeling, and engineering facilities, which enable them to address a wide variety of energy, environmental, and mineral resource research topics. Since the EERC became a part of the University of North Dakota in April 1983, it has established working relationships with more than 1300 different clients, including federal and state agencies, universities, energy exploration and production companies, utilities, research and development firms, equipment vendors, architecture and engineering firms, chemical companies, agricultural products companies, and other organizations, representing 52 nations on six continents.

Since 2003, the EERC has been providing guidance and leadership by assessing, validating, and demonstrating the technical and economic feasibility of capturing and storing carbon dioxide (CO_2) emissions from stationary sources. In addition, over the last 11 years, the EERC has successfully managed a U.S. Department of Energy (DOE)-funded consortium focused on carbon storage across a nine-state, four-province region within the central interior of North America. The consortium comprises over 100 industry partners, federal agencies, and state and regional governmental groups from the United States and beyond.

The EERC has led efforts on three large-scale commercial CO_2 storage studies that have incorporated an iterative, adaptive approach to site characterization, modeling and numerical simulation, risk assessment, and risk-based fit-for-purpose monitoring, verification, and accounting (MVA) throughout the project life cycle. Two of the efforts, the Fort Nelson Carbon Capture and Storage Feasibility Project and the Zama Acid Gas EOR (enhanced oil recovery) and CO_2 Storage Project, are recognized by the international Carbon Sequestration Leadership Forum as being uniquely qualified to fill technological gaps with regard to geologic storage of CO_2. In the third study, the EERC has been actively working with an oil company since 2010 to determine the technical and economic viability of CO_2 storage associated with commercial-scale EOR at an oil field in southeast Montana. CO_2 sourced from two natural gas-processing facilities in Wyoming is injected into an oil-bearing sandstone reservoir. The EERC is supporting geologic site characterization, modeling and simulation, and risk assessment efforts and is deploying a risk-based fit-for-purpose MVA strategy. The MVA program is demonstrating how combinations of available technologies can be integrated into an overall monitoring strategy to enhance interpretation capabilities and improve commercial EOR performance while being engineered to have minimal impact on commercial operations. The program is also evaluating how existing CO_2 storage and EOR regulatory requirements can be cost-effectively satisfied for commercial-scale projects. Over 1.5 million metric tons of CO_2 has been injected as part of this project to date.

The EERC has substantial accumulated experience and capabilities for assessing geologic CO_2 storage potential and has developed capacity estimates for numerous geologic formations, including saline formations, coal seams, and hydrocarbon reservoirs using state-of-the-art methodologies and computer software. This has involved the development of generic technical protocols as well as targeted site-specific assessments that involve both storage alone and storage in conjunction with some form of EOR. The EERC has examined CO_2 storage in many global locations, including the following:

- Reconnaissance-level regional- and subregional-scale estimates of several saline formations, including the Northern Great Plains' multibasin Madison Group, the Lower Cretaceous aquifer system, and the Broom Creek Formation.

- Three deep major coal horizons have been characterized: the Wyodak–Anderson bed in the Powder River Basin, the Harmon–Hanson interval in the Williston Basin, and the Ardley coal zone in the Alberta Basin. The total maximum CO_2 storage resource potential for all three coal deposits is approximately 8 billion tons (7.3 billion tonnes).

- Four representative real-world potential storage sites were identified and geologically modeled to achieve the goal of pairing extracted water quantity and quality, treatment options, and potential CO_2 storage sites, including Gorgon (offshore Western Australia), Ketzin (central Germany), Zama (northern Alberta, Canada), and Teapot Dome (Wyoming).

- Utilization of nine formations (Minnelusa, Broom Creek, Inyan Kara, Mission Canyon, Leduc, Keg River, Stuttgart [Germany], Qingshankou [China], and Utsira [Norway]) to better understand the effect of formation-specific characteristics on CO_2 storage resource estimates to improve existing methodologies.

- Detailed, project-specific, modeling-based estimates of storage capacity in reservoir-scale areas of the Broom Creek Formation in central North Dakota and multiple Devonian carbonate formations in northeastern British Columbia.

- Reconnaissance-level estimates of EOR-related storage in over 400 oil fields in North Dakota, South Dakota, Montana, Nebraska, Missouri, Alberta, Saskatchewan, and Manitoba.

- Detailed, modeling-based estimates of EOR-related storage of several oil fields in the Williston, Alberta, and Powder River Basins, including the Zama oil field in Alberta and the Dickinson Lodgepole Mounds and Rival oil fields in North Dakota.

- Regional characterization of storage capacity is further highlighted by an international characterization project, cofunded by the United States and Canada, which addressed the storage capacity of the basal Cambrian system, the areal extent of which exceeds more than half a million square miles.

As a result of these efforts, the EERC has established relationships with key software developers, such as Schlumberger Carbon Services (Schlumberger) and Computer Modelling Group (CMG), and has applied state-of-the-art software packages to storage sites with a range of characteristics. The product of these past efforts by the EERC and IEA Greenhouse Gas R&D Programme (IEAGHG) culminated in a technical report for CO_2 storage coefficients and an accompanying average global database. More recently, using these same research tools, the EERC and IEAGHG conducted work to investigate the extraction of formation fluids in association with CO_2 storage. This effort examined four case studies concerned with the relative effect brine extraction might have on storage capacity, sweep efficiency, and the optimization of CO_2 storage.

The EERC has extensive modeling and simulation capabilities, including multiple high-end workstation computers and a dedicated high-performance parallel computing cluster. The cluster comprises eight computing nodes consisting of 184 total superspeed threads available for modeling and simulation usage. All of the nodes/cores share a network-based power vault with a massive file server size of 120 terabytes. Additionally, the project team has access to database capabilities for managing data that will be collected and generated during the project and geographic information system software.

The EERC is also currently performing reservoir evaluations on existing and hypothetical CO_2 EOR projects to better define when a project might go from a CO_2 EOR project with associated CO_2 storage to

a balanced CO_2 storage and CO_2 EOR project and, finally, to a CO_2 storage project with associated EOR. The results of this project will help inform operators, regulators, and policy makers about the point at which an EOR project may transition to a CO_2 storage project.

The EERC is pioneering numerous forms of public outreach with regard to CO_2 storage, including fact sheets, posters, presentations, and teacher materials. Award-winning documentaries about CO_2 storage have been produced in collaboration with Prairie Public Broadcasting and broadcast on public television. Over 9600 documentary DVDs have been distributed. These documentaries (and two documentaries currently in preproduction) feature interviews and footage filmed in the United States, Brazil, Scandinavia, India, Cameroon, the United Kingdom, and continental Europe. In early 2015, filming will also take place in China to help tell the story of coal.

The EERC has extensive knowledge and expertise regarding compression and transportation of CO_2 streams, including close alignment with the Ramgen Power Systems technology now being commercialized by Dresser–Rand. The EERC worked with Ramgen and Dresser–Rand on establishing a list of possible field demonstration sites for the SuperCompressor.

The EERC has participated in conducting several carbon capture, utilization, and storage workshops, including in Mexico and China. These workshops were sponsored by APEC (Asia Pacific Economic Cooperation). The workshops in Mexico were coordinated through the Global CCS Institute, CFE, and PEMEX. The EERC presented on several topics, including storage capacity assessment, risk analysis, predictive modeling, and storage associated with EOR.

The EERC also participated in the 2014 U.S.–China Clean Energy Workshop held in Taiyuan in Shanxi Province, China. This workshop was hosted by the Shanxi Provincial Government and sponsored by DOE, China's National Energy Administration, Shenhua Group, Shanghai Industrial Company, Luan Group, and other Chinese companies. The EERC presented on emission control options.

To conduct meaningful and productive research, the EERC provides its scientists and engineers with state-of-the art research facilities. The EERC strives to provide the best possible combination of equipment, talent, leadership, demonstration facilities (over 54,000 square feet), and laboratory space (over 47,000 square feet).

The EERC demonstration facilities contain a number of venues for a variety of technologies as well as space for construction of new pilot-scale components to fit client needs. Additionally, the EERC has been involved in many projects that are demonstrated off-site but require EERC technical and field sampling expertise. Much of the mechanical design and modeling of equipment and machinery for EERC demonstration facilities is done on-site in an in-house machine shop. This allows the EERC to demonstrate technologies in a more rapid, cost-effective way.

The EERC is conducting a pilot-scale demonstration to test selected CO_2 separation and capture technologies for fossil fuel- and biomass-fired systems. The project is aimed at providing project sponsors with key technical and economic information that can be used to examine the feasibility of technologies as a function of fuel type and system configuration.

Demonstration Facility I is a 6000-square-foot structure containing seven pilot-scale units to demonstrate the combustion of solid and liquid fuels such as coal, biomass (rice hulls, switchgrass, sunflower hulls), sewage sludge, and oil slurries. The units focus on operational issues and environmental emission controls. These units serve as a cost-effective way of testing fuels and system components prior to full-scale testing.

Lorne "Mack" McEwen Demonstration Facility II is a 4000-square-foot high-bay area that contains systems including the slagging furnace system/high-temperature air furnace (HITAF), the continuous emission process simulator, and state-of-the art SO_3 removal systems. The small-scale systems allow the EERC to study the fundamentals of combustion, while the larger systems focus on scale-up and practical issues. The HITAF has been used extensively in the demonstration of a variety of emission control systems for a number of clients.

The **Process Tower** is a four-story complex housing two advanced power systems. The transport reactor development unit is an advanced power system that meets the needs of DOE's FutureGen Program, which promotes energy technologies of the future. The EERC conducts studies in support of the Wilsonville scale-up facility as well as for other industrial clients. The atmospheric circulating fluidized-bed reactor has also been used extensively for economical testing of fuels and operational issues.

Process Development Facility (high-pressure fuel processing) uses a process called hot-water drying that removes the moisture inside of solid fuels, seals their pores, and slurries the fuel for ease of use. This process has shown great promise for use with low-rank coals, biomass, and sewage sludge.

The EERC has extensive capabilities to grind, pulverize, shred, size-classify, and store a variety of solid fuels. The **Fuel Preparation and Testing Facility** can accept up to a semiload of fuel at a time and can handle fuels such as coal, biomass, and virtually any material that can be handled like coal. In addition to supporting internal EERC activities, this equipment is occasionally utilized to produce fuels for outside clients conducting limited pilot-scale tests.

In 2008, the EERC completed an additional 10,100 square feet of demonstration space dedicated to fuels of the future, which was added onto the EERC's **National Center for Hydrogen Technology®** facility. The **Fuels of the Future facility** provides essential new space for corporate partners to install more demonstration systems and gives the EERC the opportunity to expand programs that are waiting in the wings. The new 70-foot-high building was constructed to focus on the development and demonstration of technologies for the production of non-petroleum-derived liquid fuels (renewable jet, diesel, and gasoline) and hydrogen, utilizing valuable domestic energy resources.

The **Analytical Research Laboratory (ARL)** provides quality data, flexibility, and rapid turnaround time in support of research activities at the EERC. The laboratory is equipped for routine and specialized analyses of inorganic and organic constituents using laboratory procedures and analytical methods that adhere to nationally and internationally recognized or approved standards and methods. The range of ARL methods and instruments supports the chemical characterization of a variety of environmental and biological sample types, including fossil fuels, biomass, combustion by-products, geologic materials, fine particulate matter, groundwater, and wastewater. Particular attention is directed toward trace element analysis. In particular, the ARL has tested the quality of water in areas where large-scale CO_2 injection projects are under way.

The **Applied Geology Laboratory (AGL)** has the ability to perform testing ranging from basic petrographic and routine core analysis to advanced evaluations such as relative permeability and porosity distribution. Its diverse team of engineers and geologists work to provide solutions relevant to the petroleum industry, including geomechanical (uniaxial and triaxial compression), geochemical (fluid analysis, optical mineralogy/thin-section analysis, and batch reaction exposure studies), and characterization (porosity/bulk volume/grain volume/grain density, core gamma, permeability, relative permeability, and optical profilometry) analyses.

Work in the **Environmental Chemistry Laboratory** is focused on extraction and analytical method development to study the mechanisms of environmental fate, transport, and removal of organic pollutants.

The **Natural Materials Analytical Research Laboratory (NMARL)** offers analytical services designed specifically to address engineering problems in a wide range of fields. Analytical facilities combined with an experienced team of researchers provide a full range of advanced materials characterization and data interpretation, including scanning electron microscopy, x-ray fluorescence, and x-ray diffraction analyses.

Scanning Electron Microscopy

Scanning electron microscopy is an analytical technique that is capable of combining both imaging and chemical analysis. Scanning electron microscopes (SEMs) have imaging capabilities that can range from tens to tens of thousands of times of magnification. The energy-dispersive spectrometry (EDS) system allows chemical analyses of single points, small areas, lines, and even chemical mapping of the sample surface (mineral maps). The physical and chemical relationship of grains or materials next to each other is an important part of materials characterization, whether that characterization is to be used to determine the origin or chemical transformations of minerals and materials or to predict the behavior of a material when exposed to various conditions.

Instrumentation

The NMARL uses two JEOL 5800 series SEMs. One is a JEOL 5800 LV and is capable of low-vacuum (LV) imaging and analysis, and the other is a dedicated high-vacuum (HV) SEM. Both of the SEMs are equipped with Oxford Instruments EDS systems, and both have silicon drift x-ray detectors (SDD) for high-speed analysis. The EDS detector on the JEOL 5800 LV is an Oxford Instruments X-Max® detector with an 80-mm^2 analyzing crystal. The analytical system uses both Inca® and AZtec® EDS software by Oxford Instruments that is capable of point analyses, linescans, x-ray and phase mapping, and automated feature analysis. The JEOL 5800 HV uses an INCA X-act® x-ray detector with a 10-mm^2 analyzing crystal and Oxford Instruments Inca® software capable of point analysis, x-ray mapping, and automated feature analysis.

X-Ray Diffraction (XRD)

XRD is a qualitative to quantitative technique used for problems ranging from the identification of minor and clay phases to determining the anisotropic thermal expansion coefficients of novel materials. Phases are identified using the automated search–match PDF2 database and TOPAZ, the most widely used commercial software for whole-pattern fitting; the Rietveld, Pawley, and LeBail methods; indexing; quantitative-phase analysis (QPA); and ab initio structure determination. Depending on sample preparation and composition, QPA can determine the absolute amounts of crystalline phases down to 0.1 wt%. XRD can also identify the presence of amorphous material (glass) but not the composition. The system is capable of performing thin-film analysis, stress analysis, and texture analysis.

Instrumentation

The Bruker AXS D8 ADVANCE is a state-of-the-art research-grade XRD instrument for conducting crystalline-phase identification, ab initio structure determination, and QPA. The Bruker XRD is capable of conversion from Bragg–Brentano to parallel-beam geometry for various sample types. It is equipped with a nine-position sample changer and a rotating stage. The software is Bruker's EVA®, with automated search–match of the crystalline phases using the PDF2 database. QPA is done with TOPAS® software, which is a widely used commercial software package for whole-pattern fitting using the Rietveld method.

X-Ray Fluorescence (XRF)

XRF is a technique that provides the bulk chemical composition of samples. Most often, samples are powders pressed into pellets, but the fusion pellet process can be used to make glass pellets. Quick semiquantitative determinations can be made for elements with atomic numbers 5–92. XRF can be used in conjunction with chemical fractionation, a wet-chemistry technique used to quantitatively determine the modes of occurrence of the inorganic elements in coal, based on the extractability of the elements in solvents.

Instrumentation
The Rigaku ZSX PRIMUS II is a wavelength-dispersive x-ray system that is good for elements above atomic number 6 with accuracies that can be attained to the ppm level (traditional reporting to 0.1 wt%). Standards must be available for elements to be quantified.

Schlumberger Carbon Services (Schlumberger)
Schlumberger is the world's leading supplier of technology, integrated project management, and information solutions to customers working in the oil and gas industry worldwide. Employing approximately 120,000 people representing over 140 nationalities and working in more than 85 countries, Schlumberger provides the industry's widest range of products and services from exploration through production, including consulting, software, information management, and information technology (IT) infrastructure services that support core industry operational processes. Schlumberger has at its disposal experts in fields such as geological characterization, reservoir engineering, seismic processing and interpretation, data analysis, and geologic modeling. Its in-house expertise and reservoir modeling software packages provide Schlumberger the capability to assist the EERC with the data analysis and modeling activities of the proposed project.

The CETER Group, Inc. (CETER)
CETER is a scientific consulting firm specializing in statistical data analysis and environmental liability, including oil and gas- and carbon capture and storage (CCS)-related research and commercial activity. One of its areas of expertise is data analytics and applying robust statistical methods to quantify uncertainty, including Monte Carlo simulation and Bayesian inference techniques. Since 2010, CETER has been supporting the EERC with subsurface technical risk management associated with geologic CO_2 storage through the Plains CO_2 Reduction (PCOR) Partnership Program. In addition, CETER provides assistance with an EERC project focused on developing and refining the field methods used to quantify and optimize CO_2 storage capacity in all major reservoir classes for CO_2 EOR sites. For the proposed work, CETER will assist with the risk assessment and mitigation strategies.

Basin Electric Power Cooperative (BEPC)
BEPC is a wholesale electric generation and transmission cooperative based in North Dakota, which provides power to over 540,000 square miles across nine states in the United States. BEPC generates power from several different sources, including coal, gas, oil, nuclear, and distributed and renewable energy (including wind-generated). BEPC has unique and extensive business experience with the energy industry and will help to provide perspective to the North Dakota CCS effort while being supportive of economical business practices that allow continued use and support of the prevalent lignite industry in North Dakota (such as CCS opportunities).

Dakota Gasification Company (DGC)
DGC, a subsidiary of BEPC, owns and operates the coal gasification Great Plains Synfuels Plant (GPSP). GPSP is the cleanest energy plant operating in the state of North Dakota and is an international leader in technologies that capture, compress, and transport CO_2 emissions from the gasification process.

GPSP captures more CO_2 from coal conversion than any facility in the world (about 3 million tons of CO_2 per year) and is a participant in the world's largest carbon sequestration project. The facility captures and sends CO_2 through a 205-mile pipeline to Saskatchewan, Canada, for use in EOR operations, where the CO_2 will remain permanently sequestered in the depleted oil fields long after they have been abandoned. DGC is continually making research contributions to CO_2 sequestration technologies. Through ownership of its own pipeline, DGC has experience in CO_2 transportation and pipeline access for new pipelines.

Antelope Valley Station (AVS)
AVS, operated by BEPC, is the newest coal-based power plant in North Dakota. The station houses two separate 450-MW units, which began commercial operation in 1984 and 1986, respectively. AVS is located 7 miles northwest of Beulah, North Dakota, and is situated in close proximity to the lignite coal Freedom Mine owned by the Coteau Properties Company. Being located next the Freedom Mine from which it receives its fuel, AVS is referred to as a "minemouth" facility.

AVS along with GPSP and the Freedom Mine make up a $4-billion energy complex. BEPC regularly hosts tours of these facilities for member system consumers, school groups, and more with nearly 3500 people visiting the power plant each year.

ALLETE Clean Energy (ACE)
ACE was established to help transform the nation's energy landscape by creating energy solutions by way of wind, solar, biomass, hydro, natural gas, shale resources, clean coal technology, and other emerging energy innovations through acquisition or development of capital projects. ACE, BNI Energy, and Minnkota Power Cooperative (Minnkota) have launched "Project Tundra" to develop an integrated carbon capture, transportation, utilization, and storage system which will provide CO_2 to the oil fields of western North Dakota while reducing air emissions of CO_2 and ensuring continued use of the reliable and affordable generating facilities in the state (see Project State of Development). Contributions from ACE will include monetary backing for this project.

BNI Energy
BNI Energy is a wholly owned subsidiary of ALLETE, Inc., and owns and operates the Center Mine near Center, North Dakota. Originally operating as Baukol-Noonan, Inc., the Center Mine began supplying lignite coal to the nearby Milton R. Young Station in 1970. BNI currently mines approximately 4.5 million tons of lignite coal annually and reclaims roughly 210 acres of land disturbed by mining processes each year. With corporate headquarters in Bismarck, North Dakota, the BNI Energy team comprises skilled and experienced operators and professionals with expertise in mine operations, logistics, permitting, project management, and development. With many mining leases, BNI Energy has access to land that could be utilized for drilling a stratigraphic test well. BNI Energy is also equipped with a fleet of heavy equipment required for mining operations which could be utilized for preparing and maintaining injection wellsites.

North American Coal Corporation
Originally founded in 1913 as the Cleveland and Western Coal Company, the North American Coal Corporation (North American Coal), a subsidiary of NACCO Industries, Inc., is one of the United States' largest miners of lignite coal and among the largest coal producers in the country. North American Coal mines and markets lignite coal primarily as fuel for power generation and has several mining operations in six states across the United States. The Coteau Properties Company (Coteau), a subsidiary of North American Coal, owns and operates the Freedom Mine in North Dakota which produces approximately 15 million tons of lignite coal. Coteau's lignite is sold to Dakota Coal Company, a subsidiary of BEPC, part of which is, in turn, provided to BEPC's AVS. North American Coal has large amounts of land and associated pore space, including current mines and reclaimed land from previous mining operations, which could be used for injection well locations.

Minnkota Power Cooperative
Minnkota is a regional generation and transmission cooperative serving 11 member–owner distribution cooperatives. Minnkota's service area of 34,500 square miles is located in eastern North Dakota and northwestern Minnesota. Through its generation resources, which includes the Milton R. Young Station, Minnkota has some of the most competitive wholesale electrical rates in the country.

Milton R. Young
The Milton R. Young Station consists of two electric generation units (Young 1: 250 MW and Young 2: 455 MW) which are supplied with lignite coal from the nearby mines owned by BNI Coal, Ltd. Both units have been in operation for nearly 40 years (Young 1 began in 1970 and Young 2 in 1977) and have Babcock and Wilcox cyclone-fired boilers coupled to turbine generators. Young 1 is owned and operated by Minnkota, while Young 2 is owned by Square Butte Electric Cooperative and operated by Minnkota. Based in Grand Forks, North Dakota, Minnkota is a regional generation and transmission cooperative that supplies power to 11 member–owner distribution cooperatives across 34,500 square miles of eastern North Dakota and northwestern Minnesota.

Prairie Public Broadcasting (PPB)
PPB is a trusted public service dedicated to building an exciting and productive future for the prairie and its people. PPB offers a window on the world through national and regional television and radio programming; creates a forum for the most important issues facing our region with locally produced, topical programming; partners with others to foster education for all ages; and utilizes digital technology and Web services to expand those valued services. PPB will contribute by providing video equipment, technology, and staff that will create videos and documentaries of the project to educate and inspire the people of the region.

EQUIPMENT AND OTHER RESOURCES

EERC
The EERC has extensive modeling and simulation capabilities, including multiple high-end workstation computers and a dedicated high-performance parallel computing cluster. The cluster comprises eight computing nodes consisting of 232 total cores, available for modeling and simulation usage. All of the nodes/threads share a network-based power vault with a massive file server. Additionally, the project team has access to industry-level geologic modeling and simulation software, database capabilities for managing data that will be collected and generated during the project, and GIS (geographic information system) software for creating high-quality maps and images of results.

The EERC high-performance parallel computing cluster cores share a network-based storage server with a capacity of 143 terabytes. The eight nodes have following configurations:

2 × 32-core/node:
- Processor: four Intel® Xeon® E5-4627 v2 3.3GHz CPU units and each CPU unit with eight cores, total 32 cores
- Memory: 512 GB

3 × 32-core/node:
- Processor: four Intel® Xeon® X7560 2.26GHz CPU units and each CPU unit with eight cores, total 32 cores
- Memory: 128 GB

1 × 40-core/node:
- Processor: four Intel® Xeon® E7-4870 2.40GHz CPU units and each CPU unit with ten cores, total 40 cores
- Memory: 128 GB

2 × 16-core/node:

- Processor: two Intel® Xeon® E5-2690 2.90GHz CPU units and each CPU unit with eight cores, total 16 cores
- Memory: 128 GB

Seismic Data Acquisition System (SDAS)

The EERC maintains and operates a fully functional nodal seismic data acquisition system with in-house geophysicists and trained field staff capable of acquiring actively sourced 2-D lines, passive data, and unconventional acquisition geometries. System components include an accelerated weight drop seismic source and the fully integrated and user-friendly FairfieldNodal Zland seismic recorder system, consisting of 96 battery-powered autonomous three-component 5-Hz recording nodes and a data management system with specialized acquisition software.

SEISMIC SOURCE

The seismic source is the GISCO ESS850 "Turbo" Electronic Seismic Source (ESS850), manufactured by Geophysical Instrument Supply Company (GISCO) in Minneapolis, Minnesota. The source is an accelerated weight drop. It uses a high-torque electric motor and transmission to raise an 850-pound hammer against a strong elastomer. The source is trailer-mounted with a gas engine-powered generator, two heavy-duty deep discharge batteries, an integrated control system, a triggering system with a calibrated accelerometer output, and a hammer coupling plate. To match data recorded on the geophone receiver nodes with shots fired from the ESS850, the GPS (global positioning system) time of each shot is captured by the onboard source signature recorder (SSR) from Seismic Source, Inc.

SEISMIC RECORDING SYSTEM

The seismic recording system is the FairfieldNodal Zland Recorder System. The system comprises 96 three-component recorder nodes, two handheld terminals (HHTs) for deploying the nodes in the field, and a seismic management system consisting of a data server with specialized software and two networked harvester–charger racks.

The ZLand nodes are the recording units. Self-contained within a sturdy package, each is a recording system containing three orthogonally mounted 5-Hz geophones. A Li-ion battery pack powers a GPS module, GPS antenna, and 32 GB of flash memory. Programmable, they can record continuously or incrementally over a range of days. Battery life can be as long as 60 days before recharge is needed. Self-tests provide a means of checking status. The ZLand models are highly integrated with the seismic management system, and when placed in the harvester rack, they automatically download their data and commence charging. Status is communicated via LEDs in the field and graphically when in the racks.

HHTs are GPS units with software for deploying and stopping the nodes. The HHTs guide the users to preplanned locations in the field for deployment and load acquisition parameters to the nodes. HHTs are synchronized with the seismic management system to communicate as-laid coordinates and deployment times.

Prairie Public Broadcasting

Prairie Public Broadcasting is a full-service public television service and PBS affiliate with a mission to educate, inform and enlighten its viewers. The broadcast coverage area includes the state of North Dakota, western Minnesota, eastern Montana, and Manitoba, Canada. Prairie Public Broadcasting produces national award-winning documentaries that focus on the arts, history, and science. A large comprehensive high-definition studio in downtown Fargo is capable of hosting public affairs interviews, concert performances, and other televised programs. In addition, five high-definition Sony field equipment packages and five editing bays allow for the ongoing production of several projects at the same

time. Prairie Public boasts a qualified production staff of nine professionals who set the highest quality standards for every production. Their mix of producers and technical production personnel account for over 200 years of combined broadcast experience.

APPENDIX B

LETTERS OF COMMITMENT/SUPPORT

Lignite Energy Council
1016 E. Owens Avenue
P.O. Box 2277
Bismarck, ND 58502
Tel (701) 258-7117
Fax (701) 258-2755

August 16, 2016

Mr. John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Harju:

Subject: CarbonSAFE Pre-Feasibility and Feasibility Studies for Commercial-Scale Geologic Carbon Storage in Central North Dakota

I am writing to confirm the Lignite Research Council's (LRC's) commitment to join and participate in the team being assembled by the Energy & Environmental Research Center (EERC) to investigate the geologic storage of CO_2 in central North Dakota. The EERC and the rest of the team are responding to two U.S. Department of Energy (DOE) funding opportunities to investigate the deployment of commercial-scale CO_2 storage (DE-FOA-0001584 and DE-FOA-0001450).

LRC is focused on supporting the commercial deployment of CCS (carbon capture and storage) to allow continued use of North Dakota's 800-year endowment of lignite coal in a carbon-constrained world. Establishing a qualified commercial-scale CO_2 storage site in one of North Dakota's most promising geologic CO_2 storage targets will assist LRC, our member organizations, and the state of North Dakota as we plan for future development of CO_2 capture and storage in deep saline formations. Although tremendous opportunities abound to use captured CO_2 in enhanced oil recovery operations, the growth of lignite-based energy production in North Dakota will require innovative and environmentally sound practices that explore all options in managing captured CO_2. As such, LRC is committed to supporting this excellent research opportunity. The cash support will be contingent upon submission of a proposal to the North Dakota Lignite Research Program and subsequent approval by the Lignite Research Council and North Dakota Industrial Commission. Its undoubted success will contribute to the development of the CO_2 storage resource in proximity to coal-fired energy generation facilities in our region.

Should funding be awarded, LRC's support for the proposed projects is outlined below:

- For the feasibility study (Phase II), LRC will contribute $1,500,000 as cash cost share.
- Or, In the event that the pre-feasibility project is selected (Phase I), LRC will contribute $200,000 of cash support.

We wish you the best in your efforts to secure funding for the proposed project.

Sincerely,

Michael Jones
Technical Director
Lignite Research Council

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

August 17, 2016

Mr. John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Harju:

Subject: CarbonSAFE Pre-Feasibility and Feasibility Studies for Commercial-Scale Geologic Carbon Storage in Central North Dakota

I am writing to confirm Basin Electric Power Cooperative's (Basin Electric's) commitment to join and participate in the team being assembled by the Energy & Environmental Research Center (EERC) to investigate the geologic storage of CO_2 in central North Dakota. The EERC and the rest of the team are responding to two U.S. Department of Energy (DOE) funding opportunities to investigate the deployment of commercial-scale CO_2 storage (DE-FOA-0001584 and DE-FOA-0001450).

Basin Electric, a not-for-profit electricity generation and transmission cooperative, exists to build and maintain a secure power supply system in a safe, environmentally responsible manner. Together with our member rural electric systems, we serve 2.9 million electric consumers in nine states, with 69% of our entire energy portfolio coming from coal-based generation. In addition, Basin Electric has more than 15 years of experience capturing and transporting CO_2 from its Dakota Gasification Company (DGC), which sends the CO_2 to Canadian oil fields for enhanced oil recovery (EOR).

As both owners and consumers of primarily coal-based energy, Basin Electric's directors, staff, and members have a stake in ensuring that our water, air, and lands are kept pristine for our children and future generations, while supporting rural America's economies and communities. As such, we believe carbon capture and storage (CCS) could be a key technology to support the development of low-carbon energy from coal. We are convinced that Basin Electric's coal-fired facilities in North Dakota, which include DGC and Antelope Valley Station (AVS), represent a foundational component of the proposed studies. AVS, the newest coal-fired power plant in North Dakota, is located adjacent to DGC and has annual CO_2 emissions of approximately 7.0 million metric tons. DGC currently has the capacity to deliver about 3.0 million metric tons of CO_2 per year, with approximately 1.5 million metric tons available after EOR sales which may be available to supply the storage project. Together, the AVS–DGC facilities could in the future create a consistent, reliable stream of CO_2 available to the project for geologic storage if further capture technology is deployed.

As a leader in providing environmentally compliant and sustainable energy, Basin Electric is excited to continue our long-standing partnership with the EERC, the Lignite Energy Council

(LEC), and other members of the team to further the deployment of CCS in North Dakota. Should funding be awarded, Basin Electric's support for the proposed projects is outlined below:

- For the feasibility study (Phase II), Basin Electric will contribute $500,000 as cost share (both cash and in-kind).
- Or, in the event that the pre-feasibility project is selected (Phase I), Basin Electric will contribute a total of $70,000 of cash and in-kind support.

For either project, Basin Electric is committed to:

- Working with the project team to establish viable business scenarios for an integrated CCS storage project at AVS–DGC, providing expertise based on previous investigations into CCS.
- Providing support to successfully complete the project's objectives detailed in the proposed scope of work, e.g., data access, project document review.

We welcome this opportunity to partner again with the EERC, LEC, DOE, and the rest of the team on addressing the critical challenges associated with producing low-carbon energy from coal, a vital part of our nation's energy infrastructure. If you have any questions, please contact me by telephone or by e-mail.

Sincerely,

Matthew Greek
Senior Vice President, Engineering and Construction

/jjs/smm

Minnkota Power
MPC COOPERATIVE, INC.
Your Touchstone Energy® Partner

P.O. Box 13200 • Grand Forks, ND 58208-3200
1822 Mill Road • Grand Forks, ND 58203

Phone (701) 795-4000
www.minnkota.com

August 17, 2016

Mr. John Harju, Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Harju:

Subject: CarbonSAFE Pre-Feasibility and Feasibility Studies for Commercial-Scale Geologic Carbon Storage in Central North Dakota

I am writing to confirm Minnkota Power Cooperative's (Minnkota)'s commitment to join and participate in in the team being assembled by the Energy & Environmental Research Center (EERC) to investigate the geologic storage of CO_2 in central North Dakota. The EERC and the rest of the team are responding to two U.S. Department of Energy (DOE) funding opportunities to investigate the deployment of commercial-scale CO_2 storage (DE-FOA-0001584 and DE-FOA-0001450).

Minnkota is committed to providing reliable and affordable electric energy to 11 associated distribution cooperatives, three in eastern North Dakota and eight in northwestern Minnesota. This mission is not possible without sound environmental stewardship. Minnkota's primary electric generating facility is the Milton R. Young (MRY) Station which is supplied with abundant, low-cost coal from the nearby Center Mine, owned and operated by BNI Coal. The MRY Station has undergone significant upgrades to secure its future as Minnkota's jewel on the prairie. In keeping with our philosophy of environmental stewardship, Minnkota's MRY is proud to be a cornerstone piece of ALLETE Clean Energy's Project Tundra. Project Tundra focuses on the development of an integrated carbon capture, transportation, utilization, and storage system in central North Dakota.

Should funding for the proposed project be awarded, Minnkota's support is outlined below:

- For the feasibility study (Phase II), Minnkota will contribute its portion of $300,000 through BNI Energy (both cash and in-kind).
- Or, in the event that the pre-feasibility project is selected (Phase I), Minnkota will contribute its portion of $45,000 through BNI Energy of cash and in-kind support.

We welcome this opportunity to partner with the EERC, DOE, and the rest of the team pursuing opportunities to resolve challenges associated with the commercial deployment of an integrated carbon capture and storage project in North Dakota that will ensure wise future development of our state's abundant coal resource. If you have any questions, please contact me by telephone or by e-mail.

Sincerely,

Stacey Dahl

Stacey Dahl
Manager of External Affairs

ALLETE clean energy
SMART. POWERFUL. AHEAD.

30 West Superior Street, Suite 200 | Duluth, Minnesota 55802-2093 | 218.723.3988 | www.alletecleanenergy.com

Allan S. Rudeck, Jr.
President
arudeck@alletecleanenergy.com

August 18, 2016

Mr. John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Harju:

Subject: CarbonSAFE Pre-Feasibility and Feasibility Studies for Commercial-Scale Geologic Carbon Storage in Central North Dakota

I am writing to confirm ALLETE Clean Energy's (ACE's) commitment to join and participate in the team being assembled by the Energy & Environmental Research Center (EERC) that includes Minnkota Power, BNI Coal, the Lignite Energy Council (LEC), and others to investigate the geologic storage of CO_2 in central North Dakota. The EERC and the rest of the team are responding to two U.S. Department of Energy (DOE) funding opportunities to investigate the deployment of commercial-scale CO_2 storage (DE-FOA-0001584 and DE-FOA-0001450).

ACE, a rapidly growing affiliate of ALLETE Inc., was established in 2011 to acquire or develop capital projects to create energy solutions by way of wind, solar, biomass, hydro, natural gas, shale resources, clean coal technology, and other emerging energy innovations to help transform the nation's energy landscape. ACE currently owns and operates over 500 MW of clean energy facilities across the United States. ACE believes the collective long-term vision for a healthy, sustainable upper Midwest economy, including North Dakota must integrate the interests of the lignite energy industry with those of the oil and gas industry, particularly with respect to carbon management. To that extent, ACE has recently outlined an effort entitled Project Tundra, which is focused on developing carbon solutions for select utility assets. Project Tundra involves the development of an integrated carbon capture, transportation, utilization, and storage system that will ensure continued use of our reliable and affordable generating facilities while providing a valuable commodity (CO_2) to the oil fields of western North Dakota and reducing air emissions of carbon dioxide. ACE is excited to join and participate in the dynamic new partnership being developed by the EERC in pursuit of a CarbonSAFE award that will culminate in the establishment of a world-class project that integrates CO_2 captured from a coal-fired energy production facility with geologic storage and enhanced oil recovery (EOR) opportunities.

Should funding be awarded, ACE's support for the proposed projects is outlined below:

- For the feasibility study (Phase II), ACE will contribute its portion of $300,000 through ALLETE affiliate BNI Energy (both cash and in-kind).
- Or, in the event that the pre-feasibility project is selected (Phase I), ACE will contribute its portion of $45,000 through BNI Energy of cash and in-kind support.

For either project, ACE is committed to:

- Working with the project team to establish viable business scenarios for an integrated carbon capture and storage project at the Milton R. Young Station.
- Providing support to successfully complete the project's objectives detailed in the proposed scope of work, e.g., data access, engineering and project document review.

We welcome this opportunity to partner again with the EERC, DOE, and the rest of the team on addressing the critical challenges associated with producing low-carbon energy from coal, a vital part of our nation's energy infrastructure. If you have any questions, please contact me by telephone or by e-mail.

Sincerely,

Allan Rudeck
President
ALLETE Clean Energy

BNI energy
AN ALLETE COMPANY

WADE BOESHANS
President and General Manager

August 17, 2016

Mr. John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Harju:

Subject: CarbonSAFE Pre-Feasibility and Feasibility Studies for Commercial-Scale Geologic Carbon Storage in Central North Dakota

I am writing to confirm BNI Coal's (BNI's) commitment to join the team being assembled by the Energy & Environmental Research Center (EERC) that includes ALLETE Clean Energy, Minnkota Power, the Lignite Energy Council (LEC), and others to investigate the geologic storage of CO_2 in central North Dakota. The EERC and the rest of the team are responding to two U.S. Department of Energy (DOE) funding opportunities to investigate the deployment of commercial-scale CO_2 storage (DE-FOA-0001584 and DE-FOA-0001450).

BNI is developing North Dakota's abundant coal energy resource. At its Center Mine in Oliver County, North Dakota, BNI mines and reclaims about 200 acres a year to supply lignite coal to fuel the nearby Milton R. Young Generation Station. The Young Station consumes virtually all of the coal produced at Center Mine under agreements in place through 2037. The Young Station generates low-cost, reliable, domestic energy for customers in North Dakota and Minnesota. It's the people of BNI—mostly native North Dakotans—who have created the company's success. BNI employees are committed to safely and responsibly utilizing our energy resources to balance coal mining with the environment so that we leave the land as productive as we found it. In keeping with that vision, BNI is pleased to be a part of the team pursuing opportunities to resolve challenges associated with developing commercial-scale geologic storage of CO_2 for an integrated carbon capture and storage project in North Dakota that will ensure responsible future utilization of our state's abundant coal resource.

Should funding be awarded, BNI's support for the proposed projects is outlined below:

- For the feasibility study (Phase II), BNI will contribute $300,000 cash and in-kind suppot as cost share.
- In the event that the pre-feasibility project is selected (Phase I), BNI will contribute a total of $45,000 of cash and in-kind support as cost share.

For either project, BNI is committed to:

- Providing support as needed to successfully complete the project's objectives detailed in the proposed scope of work, e.g., participation in project meetings.

We welcome this opportunity to partner with the EERC, DOE, and the rest of the team on addressing the critical challenges associated with producing low-carbon energy from coal, a vital part of our nation's energy infrastructure. If you have any questions, please contact me by telephone or by e-mail.

Sincerely,

Wade Boeshans
President and General Manager
BNI Energy

August 18, 2016

Mr. John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Re: CarbonSAFE Pre-Feasibility and Feasibility Studies for Commercial-Scale Geologic Carbon Storage in Central North Dakota

Dear Mr. Harju:

I am writing to confirm The North American Coal Corporation's (NACoal's) commitment to join the team being assembled by the Energy & Environmental Research Center (EERC) to investigate the geologic storage of CO_2 in central North Dakota. The EERC and the rest of the team are responding to two U.S. Department of Energy (DOE) funding opportunities to investigate the deployment of commercial-scale CO_2 storage (DE-FOA-0001584 and DE-FOA-0001450).

NACoal is developing North Dakota's abundant coal energy resource. At its Freedom Mine in Mercer County, North Dakota, NACoal mines 15 million tons a year, making it the largest lignite mine in the United States and supplying the nearby Dakota Gasification Company and Antelope Valley Station facilities. NACoal works closely with its customers to ensure coal quality enhances daily plant performance and operation. Customers know the quality of every shipment of coal before they receive it. This information helps them handle their fuel to meet production and emission goals.

NACoal has been recognized as a leader in land reclamation and environmental protection by industry peers and government agencies at all levels and is committed to maintaining, protecting, and enhancing the quality of the environment at each of its operations. In keeping with that commitment, NACoal is pleased to be a part of the team pursuing opportunities to resolve challenges associated with developing commercial-scale geologic storage of CO_2 for an integrated carbon capture and storage project in North Dakota that will ensure wise future development of our state's abundant coal resource.

Should funding be awarded, NACoal's support for the proposed projects is outlined below:

- For the feasibility study (Phase II), NACoal will contribute $100,000 as cost share (in-kind).
- In the event that the pre-feasibility project is selected (Phase I), NACoal will contribute a total of $15,000 of in-kind support.

We welcome this opportunity to partner with the EERC, DOE, and the rest of the team to address the critical challenges associated with producing low-carbon energy from coal, a vital part of our nation's energy infrastructure. If you have any questions, please contact me by telephone or by e-mail.

Sincerely,

NORTH AMERICAN COAL CORPORATION

David Straley
Director, External Affairs

The North American Coal Corporation
2000 Schafer Street, Suite D • Bismarck, North Dakota 58501-1201 • 701-258-2200 • Fax 701-222-7594 • www.nacoal.com

Schlumberger
Carbon Services

Wayne Rowe
Schlumberger Carbon Services
1875 Lawrence Street, Suite 810
Denver, CO 80202 USA

August 22, 2016

Mr. Wesley Peck
Principal Geologist, Geosciences Group Lead
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Peck:

Subject: EERC Proposal No. 2017-0012 Entitled "North Dakota Integrated Carbon Storage Complex Feasibility Study"

I am writing to confirm Schlumberger's commitment to participate on the team that is being assembled by the Energy & Environmental Research Center (EERC) to investigate carbon storage in central North Dakota in response to U.S. Department of Energy (DOE) Funding Opportunity Announcement DE-FOA-0001450.

Schlumberger is a recognized leader in modeling complex geologic systems, reservoir evaluations, and the management of CO_2, with decades of experience in field testing for the oil and gas industry. As such, Schlumberger is focused on providing practical solutions for the characterization, modeling, and simulation of oil, gas, and saline reservoirs to assist in answering challenging questions associated with the identification of suitable targets for CO_2 injection, reservoir behavior in response to injection, and the long-term fate of the injected fluid. Schlumberger's software, coupled with the EERC's research capabilities and wealth of knowledge with regard to geological analysis and characterization, 3-D geocellular modeling, and geologic storage of CO_2, creates an ideal formula to conduct the proposed feasibility assessment of the geologic storage of CO_2 for an integrated carbon capture and storage project in central North Dakota.

Schlumberger is committed to providing services in the form of developing a drilling, logging, and coring plan for two stratigraphic test wells in the project area, as well as conducting the drilling, logging, and coring activities for each well (valued at $4,406,620). The results of these activities will support the geologic characterization of the storage site. Additionally, Schlumberger is willing to provide cash-equivalent cost share in the form of critical project software licenses (two licenses for Petrel) and maintenance over the course of the 24-month project, valued at an amount not less than $2,308,096. We understand this cost share will be used to leverage DOE funding and, therefore, certify that the funding is from nonfederal sources.

We welcome this opportunity to again collaborate with the EERC and the rest of the team on addressing the critical challenges associated with the development of a commercial-scale CO_2 storage site in central North Dakota.

If you have any questions, please contact me by telephone at (303) 594-1219 or by e-mail at rowe5@slb.com.

Sincerely,

Wayne Rowe

Wayne Rowe
Carbon Services Business Manager

Carbon Services Reference Number

COMPUTER MODELLING GROUP INC.

Paragon Center One
450 Gears Road, Suite 860
Houston, Texas
U.S.A. 77067

Phone: (281) 872-8500
Fax: (281) 872-8577
E-mail: cmgl@cmgl.ca
Website: www.cmgl.ca

August 18, 2016

Mr. Wesley Peck
Principal Geologist, Geosciences Group Lead
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Peck:

Subject: EERC Proposal No. 2017-0012 Entitled "North Dakota Integrated Carbon Storage Complex Feasibility Study"

I am writing to confirm Computer Modelling Group Ltd.'s (CMG's) commitment to partner with the team that is being assembled by the Energy & Environmental Research Center (EERC) to investigate carbon storage in central North Dakota in response to U.S. Department of Energy (DOE) Funding Opportunity Announcement DE-FOA-0001450.

CMG is focused on providing practical solutions for modeling and simulation of oil and gas reservoirs and saline formations to assist in answering challenging questions associated with the long-term fate of CO_2 and other fluids injected into these reservoirs. CMG's software and the EERC's research capabilities, established relationship with members of the project team, carbon capture and storage (CCS) expertise, geological knowledge, and subsurface static and dynamic modeling proficiency create an ideal formula to conduct a feasibility assessment of the geologic storage of CO_2 for an integrated CCS project in central North Dakota.

As indicated in the subject proposal, CMG is willing to provide in-kind cost share in the form of reservoir simulation software licenses, tools, and technical support. These services will be provided for the duration of the 2-year project to support the proposed scope of work. CMG's license fee for leasing one copy each of GEM (full-field unlimited grid cell version), BUILDER, RESULTS, WINPROP, and CMOST plus two GEM parallel tokens (allowing GEM to run in eight-way parallel mode) is US$188,200 per year ($376,400 total for 2 years). The portion contributed by CMG as in-kind cost share will be US$169,380 per year ($338,760 total for 2 years). The remaining US$18,820 per year ($37,640 total for 2 years) in license fees will be paid by the EERC.

We welcome this opportunity to collaborate with the EERC and the rest of the team on addressing the critical challenges associated with the development of a commercial-scale CO_2 storage site in central North Dakota.

Sincerely,

Jim Erdle
Vice President – USA and Latin America

Prairie Public Broadcasting, Inc.
Television
Radio
Education Services
Enterprises

August 19, 2016

Mr. Wesley Peck
Principal Geologist, Geosciences Group Lead
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Peck:

Subject: North Dakota Integrated Carbon Storage Complex Feasibility Study

Prairie Public Broadcasting is pleased to participate in the Energy & Environmental Research Center's (EERC's) proposed North Dakota Integrated Carbon Storage Complex Feasibility Study.

As part of this project, Prairie Public agrees to undertake activities as follows:

- Collect video footage in the feasibility study target area.
- Collect interviews of project participants.
- Produce three professional-quality, high-definition video shorts (9 minutes total)

Through its locally produced, topical programming, Prairie Public Broadcasting creates a forum for the most important issues facing our region and partners with others to foster education for all ages. Since the fall of 2003, Prairie Public has partnered with the EERC's PCOR Partnership Program, part of the U.S. Department of Energy's Regional Carbon Sequestration Partnerships. Together, Prairie Public and the PCOR Partnership outreach team have coproduced five CO_2 sequestration documentaries as well as more than 50 video clips for presentations and streaming on the Web. Prairie Public feels that participation in the EERC's North Dakota Integrated Carbon Storage Complex Feasibility Study is a good fit with our mission to provide quality radio, television, and public media services that educate, involve, and inspire the people of the prairie region.

Prairie Public Broadcasting costs are estimated at $39,000, of which Prairie Public will contribute an estimated $23,500 as in-kind cost share.

Sincerely,

Robert Dambach
Director of Television
Prairie Public Broadcasting

Corporate Offices
207 North 5th Street
PO Box 3240
Fargo ND 58108-3240
701-241-6900 800-359-6900
701-239-7650 Fax

Bismarck Office
1814 North 15th Street
Bismarck ND 58501
701-224-1700
701-224-0555 Fax

Prairie Public, Manitoba
PO Box 2640
Winnipeg MB R3C 4B3

www.prairiepublic.org
info@prairiepublic.org

State of
North Dakota
Office of the Governor

Jack Dalrymple
Governor

August 16, 2016

Mr. John A. Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear John:

Subject: Support for North Dakota Carbon Storage Complex

I am writing to express my support for the Energy & Environmental Research Center's (EERC's) efforts to secure funding through the U.S. Department of Energy's CarbonSAFE funding opportunities to investigate carbon storage in North Dakota.

As the Governor of North Dakota, I chair the North Dakota Industrial Commission which is the primary regulator of North Dakota's vast subsurface mineral resources. North Dakota has a long history of responsible development and environmental leadership. I commend the EERC for its long-term commitment to making geologic sequestration of CO_2 a viable option in our quest for low-carbon solutions.

North Dakota's energy industries are global leaders in energy development and production, implementing long-term strategies that provide meaningful and abundant contributions to our nation's energy needs. This includes fossil fuels as well as renewable resources. The projects proposed by the EERC will facilitate continual environmental progress in the utilization of our state's abundant natural resources by investigating the feasibility of developing an integrated carbon storage complex.

I strongly support the efforts of the EERC and look forward to the exciting opportunities this work will bring to the state of North Dakota and our country in resolving our energy challenges.

Sincerely,

Jack Dalrymple
Governor

37:81:77

600 E Boulevard Ave. • Bismarck, ND 58505-0001 • Phone: 701.328.2200 • Fax: 701.328.2205 • www.governor.nd.gov

JOHN HOEVEN
NORTH DAKOTA
338 RUSSELL SENATE OFFICE BUILDING
TELEPHONE: (202) 224-2551
FAX: (202) 224-7999
hoeven.senate.gov

United States Senate

WASHINGTON, DC 20510

COMMITTEES:
AGRICULTURE
APPROPRIATIONS
ENERGY AND NATURAL RESOURCES
INDIAN AFFAIRS

August 15, 2016

Mr. John A. Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear John,

I write to express my support for the Energy & Environmental Research Center's (EERC's) efforts to secure funding through the U.S. Department of Energy's CarbonSAFE funding opportunities to investigate carbon storage in North Dakota.

As you know, as governor of North Dakota I worked to implement a regulatory framework that provides certainty and encourages innovation to produce more energy with better environmental stewardship. In 2008, I created the North Dakota CO2 Storage Workgroup, which was tasked to develop regulatory framework for the long-term storage of CO2. The result of this workgroup was Senate Bill 2095, which I signed into law in 2009. This legislation granted regulatory authority over geologic sequestration of CO2 to the North Dakota Industrial Commission and established trust funds for state oversight and for long-term liability. In particular, I call your attention to these long-term liability provisions as one of several critical elements that highlight North Dakota's leadership in making geologic sequestration a reality.

North Dakota is at the forefront of energy development and production. Our state continues to investigate long-term strategies that incorporate all energy resources—traditional and emerging—to meet the nation's growing energy demand in an environmentally responsible manner. The projects proposed by the EERC will investigate the feasibility of housing an integrated carbon storage complex in North Dakota, leading to expanded opportunities for the state's coal and other energy industries.

I support the exciting opportunities the proposed projects will bring to the state of North Dakota and the nation in resolving our energy challenges.

Sincerely,

John Hoeven

John Hoeven
U.S. Senator

HEIDI HEITKAMP
NORTH DAKOTA
HART SENATE BUILDING 110
WASHINGTON, DC 20510
PH: 202-224-2043
FAX: 202-224-7776
TOLL FREE: 1-800-223-4457
http://www.heitkamp.senate.gov

United States Senate

WASHINGTON, DC 20510

COMMITTEES:
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INDIAN AFFAIRS
SMALL BUSINESS AND ENTREPRENEURSHIP

August 17, 2016

Mr. John A. Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear John:

I am writing to express my support for the Energy & Environmental Research Center's (EERC's) proposal to the U.S. Department of Energy's recent funding opportunity announcement to investigate geologic carbon storage in North Dakota.

As you know, I have been relentless in my support for our state's all-of-the-above energy industry – and for the world-class energy research across multiple disciplines undertaken by the EERC. In particular, technological advances in clean coal technology have been a priority of mine. I have introduced and worked on multiple pieces of legislation looking to advance clean coal technology – with a focus on those policies that would encourage research, development, and implementation of Carbon Capture Utilization and Storage (CCUS) technologies. I most recently introduced legislation that would incentivize geologic storage of CO_2 through the use of 45Q tax credits. The type of research suggested in the EERC's proposal would directly complement that legislation.

North Dakota is among the nation's premier states in energy production and environmental conservation. I am a proponent of an "all of the above" strategy for the development and production of all of the state's energy resources—conventional and renewable – and believe that North Dakota's energy research and policies should serve as a model for the rest of the country. The EERC's proposed efforts will fast-track the development of an integrated carbon storage complex in North Dakota, which will lead to an expansion of the opportunities for our state's coal and other complementary energy industries.

I am a strong advocate for the work being done at EERC and remain supportive and committed to the opportunities that proposed projects like the geologic carbon storage proposal currently being pursued promise the state of North Dakota and the nation.

Sincerely,

Heidi Heitkamp

Heidi Heitkamp
United States Senator

BISMARCK OFFICE:
228 FEDERAL BUILDING
220 EAST ROSSER AVENUE
BISMARCK, ND 58501
PH: 701-258-4648
FAX: 701-258-1254

DICKINSON OFFICE:
40 1ST AVENUE WEST
SUITE 202
DICKINSON, ND 58601
PH: 701-225-0974
FAX: 701-225-3287

FARGO OFFICE:
306 FEDERAL BUILDING
657 SECOND AVENUE NORTH
FARGO, ND 58102
PH: 701-232-8030 – 1-800-223-4457
FAX: 701-232-6449

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GRAND FORKS, ND 58201
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105 FEDERAL BUILDING
100 FIRST STREET S.W.
MINOT, ND 58701
PH: 701-852-0703
FAX: 701-838-8196

KEVIN CRAMER
NORTH DAKOTA

WASHINGTON D.C. OFFICE:
1032 LONGWORTH BUILDING
WASHINGTON, DC 20515
202-225-2611

BISMARCK OFFICE:
220 EAST ROSSER AVENUE
SUITE 328
BISMARCK, NORTH DAKOTA 58501
701-224-0355

CONGRESS OF THE UNITED STATES
HOUSE OF REPRESENTATIVES
WASHINGTON, DC 20515

FARGO OFFICE:
3217 FIECHTNER DRIVE, SUITE D
FARGO, NORTH DAKOTA 58103
701-356-2216

MINOT OFFICE:
315 MAIN STREET SOUTH, SUITE 203
MINOT, NORTH DAKOTA 58701
701-839-0255

GRAND FORKS OFFICE:
CENTER FOR INNOVATION FOUNDATION BUILDING
4200 JAMES RAY DRIVE, OFFICE 600
GRAND FORKS, NORTH DAKOTA 58202
701-738-4880

August 15, 2016

Mr. John A. Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Subject: Support for North Dakota Carbon Storage Complex

Dear Mr. Harju,

I am writing to express my support for the Energy & Environmental Research Center's (EERC's) efforts to secure funding through the U.S. Department of Energy's CarbonSAFE initiative to investigate carbon storage in North Dakota.

In my role as the lone North Dakota member of the U.S. House of Representatives, I have the privilege to showcase our state's vibrant energy resources and those enterprises which lead their environmentally responsible production. I am particularly proud of my continuous opportunities to highlight the ongoing leadership of the EERC in formulating an economically viable low-carbon future for our nation and world.

The EERC's proposed efforts will examine the potential development of a world-class and world-scale carbon storage enterprise in North Dakota. I am confident this will further propel North Dakota and the United States' leadership in the pursuit of energy solutions.

I strongly support the EERC's efforts, which will lead to exciting opportunities for the state of North Dakota and the nation in resolving near- and long-term energy challenges.

Sincerely,

Kevin Cramer
Member of Congress

North Dakota
LEGENDARY

August 17, 2016

Mr. John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear John:

Subject: Support for North Dakota Carbon Storage Complex

I am writing to confirm the support of the EmPower North Dakota Commission and its desire to join the team that is being assembled by the Energy & Environmental Research Center in response to U.S. Department of Energy funding opportunities to investigate carbon storage in North Dakota (DE-FOA-0001584 and DE-FOA-00011450).

North Dakota is proactive and aggressive in addressing energy development and serves as a model for America in fostering innovative, long-term energy strategies to meet our nation's growing energy demand in an environmentally responsible manner. As such, in 2007 the state Legislature formed the 16-member EmPower North Dakota Commission, which includes representatives from all major energy industries in North Dakota. The strategic partnership developed between these long-standing and emerging energy industries enables them to work together as critical thinkers for the development of the state's energy resources and meet the state's and nation's energy needs without government mandates.

In keeping with its vision, the EmPower North Dakota Commission is excited to be a part of the team pursuing opportunities to resolve challenges associated with the commercial deployment of an integrated carbon capture and storage project in North Dakota.

Sincerely,

Alan Anderson
Chairman
EmPower North Dakota Commission

Department of Mineral Resources

Lynn D. Helms – Director

North Dakota Industrial Commission
www.dmr.nd.gov

August 19, 2016

Mr. John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Harju:

Subject: Letter of Support for CarbonSAFE Funding Opportunity

The North Dakota Industrial Commission's (NDIC's) Department of Mineral Resources (DMR) is pleased to provide the Energy & Environmental Research Center (EERC) with this letter of support for your proposed studies to investigate commercial-scale geologic carbon storage in central North Dakota, in response to the U.S. Department of Energy's CarbonSAFE funding opportunities (DE-FOA-0001584 and DE-FOA-0001450).

As you know, North Dakota is one of the nation's largest providers of energy, primarily in the forms of petroleum and electricity generated from coal-fired power plants. Because energy production is such a vital part of the North Dakota economy, we are very supportive of the development of technologies that will enable the continued use of our energy resources in an environmentally responsible manner.

We are particularly excited about the proposed CarbonSAFE opportunity because it will help support the continued use of coal-based electricity in a carbon-constrained world. If successfully funded, the EERC's CarbonSAFE project will characterize storage sites in North Dakota to help qualify a portion of our vast CO_2 storage potential. The results of the project will provide the coal industry with data and knowledge critical to implementing commercial-scale CO_2 storage in deep saline formations across the state.

Should the feasibility study be funded, we understand the EERC is planning to permit and drill two stratigraphic test wells under NDIC guidelines. To support this effort, NDIC DMR is prepared to work with the EERC to ensure all required documents are submitted with the permit applications and that they are reviewed and approved in a timely manner.

In closing, we look forward to working with the EERC on this important project. We wish you the best in your efforts to secure this funding opportunity.

Sincerely,

Lynn D. Helms
Director

ND ASSOCIATION OF OIL AND GAS PRODUCING COUNTIES

August 17, 2016

Mr. John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Harju:

Subject: CarbonSAFE Pre-Feasibility and Feasibility Studies for Commercial-Scale Geologic Carbon Storage in Central North Dakota

I am writing to confirm the North Dakota Association of Oil and Gas Producing Counties' (NDAOGPC's) support for the team being assembled by the Energy & Environmental Research Center (EERC) to investigate the geologic storage of CO_2 in Mercer and Oliver Counties. The EERC and the rest of the team are responding to two U.S. Department of Energy (DOE) funding opportunities to investigate the deployment of commercial-scale CO_2 storage (DE-FOA-0001584 and DE-FOA-0001450).

The mission of NDAOGPC, and its affiliated association of North Dakota Coal Conversion Counties, is to support sustainable energy development and responsible revenue sharing for its members and promote the greater good of North Dakota. This vision reflects our long-term goals to be the trusted and unified voice promoting prosperity and improving quality of life by influencing decisions affecting members, counties, cities, and schools. To that end, NDAOGPC stands behind the development of mechanisms that will ensure continued use of our reliable and affordable coal-fired energy generation facilities, especially toward providing a valuable commodity (CO_2) to the oil fields of western North Dakota for the long-term sustainability of that industry.

We welcome this opportunity to partner with the EERC, DOE, and the rest of the team on addressing the critical challenges associated with producing low-carbon energy from coal, a vital part of our nation's energy infrastructure. If you have any questions, please contact me by telephone or by e-mail.

Sincerely,

Vicky Steiner

Vicky Steiner, Executive Director

August 19, 2016

Mr. Charles Gorecki
Director of Subsurface R&D
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Gorecki:

Subject: Access to Land

We are writing to confirm our tentative agreement to allow the Energy & Environmental Research Center (EERC) access to 1 to 5 acres in the N½ of the NE¼ quarter of Section 29, Township 145 North, Range 89 West, Mercer County, North Dakota, to permit and drill a stratigraphic test well. Based on our initial conversations, we anticipate being compensated for this access at $5000/acre, should the research project be awarded and the well be drilled on our property. We also understand that the estimated time frame needing access to the land may be up to 2 months. The EERC will obtain all necessary state permits required to drill the well. Following completion of all well-testing procedures, the well will be plugged and abandoned following stipulations dictated by North Dakota Industrial Commission procedures and the land restored to its original configuration.

We look forward to being part of your investigation to ensure wise future development of North Dakota's abundant coal resource.

Sincerely,

Marc and Jodi Schriefer
7000 County 26
Golden Valley, ND 58541

APPENDIX C

EERC KEY PERSONNEL

WESLEY D. PECK
Principal Geologist, Geoscience Group Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5195, Fax: (701) 777-5181, E-Mail: wpeck@undeerc.org

Education and Training

M.S., Geology, University of North Dakota, 1992. Thesis: The Stratigraphy and Sedimentology of the Sentinel Butte Formation (Paleocene) in South-Central Williams County, North Dakota.
B.S., Earth Science, North Dakota State University, 1987.

Professional Experience

2015–Present: Principal Geologist, Geoscience Group Lead, EERC, UND. Mr. Peck leads a staff of geoscientists involved in subsurface resource development with an emphasis on the Williston and Powder River Basins. He also serves as task lead and principal investigator of the regional geologic characterization component of the Plains CO_2 Reduction Partnership (PCOR) Partnership Program, which focuses on carbon dioxide storage in central North America. Mr. Peck's principal areas of interest and expertise include geology, geographic information systems (GIS), cartography, and information graphics. He is also the project manager for a U.S. Department of Energy (DOE)-funded program to evaluate the potential for residual oil zones in the Williston and Powder River Basins.

2011–2015: Research Manager, EERC, UND. Mr. Peck's responsibilities include overseeing a staff of geologists and GIS specialists involved with oil and gas research activities in the Williston Basin as well as regional geologic characterization activities associated with the PCOR Partnership.

1991–2011: Research Scientist, EERC, UND. Mr. Peck's responsibilities included overseeing major GIS activities at the EERC, serving as task leader for the regional characterization component of the PCOR Partnership, as well as report and proposal writing.

1989–1991: Graduate Research Assistant, EERC, UND. Mr. Peck's responsibilities included acquisition and management of geologic data related to Cretaceous and Tertiary geology of the Williston Basin. Mr. Peck also assisted in the collection of Cretaceous and Tertiary fossils and stratigraphic information in western North Dakota and eastern Montana.

Publications

Glazewski, K.A., Grove, M.M., Peck, W.D., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2015, Characterization of the PCOR Partnership region: Plains CO_2 Reduction (PCOR) Partnership value-added report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-02-14, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

Peck, W.D., 2015, Plains CO_2 Reduction (PCOR) Partnership perspective: Presented at North American Energy Ministers Climate Change and Energy Collaboration—Advancing the Deployment of CCUS, Austin, Texas, December 1–3, 2015.

Peck, W.D., and Gorecki, C.D., 2015, Geologic modeling and simulation at the Aquistore site—a guide to MVA deployment: Presented at the 14th Annual Carbon Capture, Utilization & Storage Conference, Pittsburgh, Pennsylvania, April 28 – May 1, 2015.

Klenner, R.C.L., Braunberger, J.R., Dotzenrod, N.W., Bosshart, N.W., Peck, W.D., and Gorecki, C.D., 2014, Training image characterization and multipoint statistical modeling of clastic and carbonate formations: Presented at the 2014 Rocky Mountain Section AAPG Annual Meeting, Denver, Colorado, July 20–22, 2014.

Peck, W.D., Glazewski, K.A., Braunberger, J.R., Grove, M.M., Bailey, T.P., Bremer, J.M., Gorz, A.J., Sorensen, J.A., Gorecki, C.D., and Steadman, E.N., 2014, Broom Creek Formation outline: Plains CO_2 Reduction (PCOR) Partnership Phase III value-added report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2014-EERC-09-09, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

Peck, W.D., Glazewski, K.A., Klenner, R.C.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Improvements in the application of CO_2 storage efficiency values for deep saline formations: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 1 Deliverable D7 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2014-EERC-10-09, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Peck, W.A., Glazewski, K.A., Klenner, R.C.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, A workflow to determine CO_2 storage potential in deep saline formations: Energy Procedia, v. 63, p. 5231–5238.

Peck, W.D., Buckley, T.D., Battle E.P., and Grove, M.M., compilers and creators, 2013, Plains CO_2 Reduction (PCOR) Partnership atlas (4th ed., rev.): Prepared for the U.S. Department of Energy National Energy Technology Laboratory and the PCOR Partnership, Grand Forks, North Dakota, Energy & Environmental Research Center, 124 p.

Synergistic Activities

- Leads regional characterization activities for the PCOR Partnership Program to determine CO_2 storage resource potential of viable saline reservoirs in the central part of North America.
- Led geologic modeling and simulation assessment of CO_2 storage resource of the 500,000-mi^2 basal saline aquifer system of the Williston and Alberta Basins.
- Served on the DOE review committee for the development of a CO_2 storage resource methodology for organic-rich shales.
- Leads a task focused on evaluating aspects involved with improving CO_2 storage resource estimation methodologies in conjunction with commercial enhanced oil recovery operations.
- Serves on the DOE committee for development of a best practices manual on site characterization for geological storage of CO_2.

RYAN J. KLAPPERICH
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Education and Training

M.S., Geology, University of North Dakota, 2008.
Graduate Certificate, Geographic Information Science, 2007.
B.S., Geology, University of North Dakota, 2005.
B.A., Honors Program, University of North Dakota, 2005.

Research and Professional Experience

2009–Present: Senior Hydrogeologist, EERC, UND. Mr. Klapperich works with the Oil and Gas Group and the Plains CO_2 Reduction (PCOR) Partnership at the EERC, where he is actively involved in many site characterization and CO_2-monitoring activities including the following:

- Served as the co-principal investigator (PI) on a project principally funded by the IEA Greenhouse Gas R&D Programme (IEAGHG) focused on understanding the use of active reservoir management (ARM) schemes to enhance CO_2 storage and reduce monitoring, verification, and accounting (MVA) costs.
- Serves as the Co-PI on the recently awarded brine extraction and storage test (BEST) project, which will demonstrate the use of ARM techniques to improve reservoir storage potential in saline formations with CO_2 storage potential.
- Serves as the task lead for the PCOR Partnership's Water Working Group, a working group comprising members of the U.S. Department of Energy 's (DOE's) Regional Carbon Sequestration Partnership (RCSP) Program focused on developing an understanding and solutions for issues at the nexus of carbon capture and storage (CCS) and water.

Mr. Klapperich's principal areas of interest and expertise focus on CO_2 enhanced oil recovery (EOR) and storage, including geologic site characterization, monitoring program assessments, design and implementation of near-surface monitoring programs, and interpretation of monitoring data. Other areas of interest include hydrogeology, geographic information systems (GIS), CO_2 sequestration, and related environmental issues.

2007–2009: Laboratory Technician, North Dakota Geological Survey Core and Sample Library, Grand Forks, North Dakota. Mr. Klapperich's responsibilities included staging and taking digital photographs of core sample inventory; processing and manipulating digital photographs; updating, cataloging, and reboxing core and sample inventory; cutting unprocessed cores into slabs; processing and cataloging new inventory; assisting clients with retrieving and handling samples; and operating a forklift.

2006–2007: Research Assistant, Geology and Geological Engineering, UND. Mr. Klapperich's responsibilities included refining new analytical laboratory procedures, performing analytical procedures in the Environmental Analytical Research Laboratory, and analyzing collected data; performing literature reviews and preparing materials for grant submissions, progress reports, and presentations/publications; maintaining proper quality control and quality assurance while working as a team member with other students and lab personnel; and provided tours of exhibits in Leonard Hall.

Publications

Liu, G., Gorecki, C.D., Bremer, J.M., Klapperich, R.J., and Braunberger, J.R., 2015, Storage capacity enhancement and reservoir management using water extraction—four site case studies: International Journal of Greenhouse Gas Control, v. 35, p. 82–95.

Kalenze, N.S., Hamling, J.A., Klapperich, R.J., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Bell Creek test site – monitoring experimental design package: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 5 Deliverable D43 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-11-08, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Klapperich, R.J., Liu, G., Stepan, D.J., Jensen, M.D., Gorecki, C.D., Steadman, E.N., Harju, J.A., and Nakles, D.V., 2014, IEAGHG investigation of extracted water from CO_2 storage—potential benefits of water extraction and lesson learned: Energy Procedia, v. 63, p. 7173–7186.

Klapperich, R.J., Stepan, D.J., Jensen, M.D., Gorecki, C.D., Steadman, E.N., Harju, J.A., Nakles, D.V., and McNemar, A.T., 2014, The nexus of water and CCS—a regional carbon sequestration partnership perspective: Energy Procedia, v. 63, p. 7162–7172.

Gorecki, C.D., Liu, G., Bailey, T.P., Sorensen, J.A., Klapperich, R.J., Braunberger, J.R., Steadman, E.N., and Harju, J.A., 2013, The role of static and dynamic modeling in the Fort Nelson CCS Project: Energy Procedia, v. 37, p. 3733–3741.

Klapperich, R.J., Cowan, R.M., Gorecki, C.D., Liu, G., Bremer, J.M., Holubnyak, Y.I., Kalenze, N.S., Knudsen, D.J., Saini, D., Botnen, L.S., LaBonte, J.L., Stepan, D.J., Steadman, E.N., Harju, J.A., Basava-Reddi, L., and McNemar, A., 2013, IEAGHG investigation of extraction of formation water from CO_2 storage: Energy Procedia, v. 37, p. 2479–2486.

Liu, G., Gorecki, C.D., Saini, D., Bremer, J.M., Klapperich, R.J., and Braunberger, J.R., 2013, Four-site case study of water extraction from CO_2 storage reservoirs: Energy Procedia, v. 37, p. 4518–4525.

Gorecki, C.D., Hamling, J.A., Klapperich, R.J., Steadman, E.N., and Harju, J.A., 2012, Integrating CO_2 EOR and CO_2 storage in the Bell Creek oil field, *in* 2012 Carbon Management Technology Conference: Orlando, Florida, February 7–9, 2012, Proceedings, CMTC 151476.

IEA Greenhouse Gas R&D Programme (IEAGHG), 2012, Extraction of formation water from CO_2 storage: Report 2012/12, Cheltenham, United Kingdom, IEA Greenhouse Gas R&D Programme, November.

Botnen, B.W., Klapperich, R.J., Gorecki, C.D., and Steadman, E.N., 2011, Bell Creek test site – hydrogeological experimental design package: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Deliverable D34 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2011-EERC-10-03, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Synergistic Activities

- PI for the DOE RCSP's WWG, which is focused on identifying impacts of CO_2 injection on water-related issues such as brine displacement, pressurization effects, and the potential impact on potable waters.
- Co-PI for several projects, including the IEAGHG-sponsored study on "Extraction of Formation Water from CO_2 Storage."
- Actively involved with research on carbon capture and storage (CCS) monitoring strategies for the PCOR Partnership's Phase 3 Bell Creek combined enhanced oil recovery (EOR) and CCS program.
- Actively involved with research on CCS site characterization strategies for the PCOR Partnership's Phase 3 Bell Creek combined EOR and CCS program.

LONNY L. JACOBSON
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Education and Training

B.A., Economics, University of North Dakota, 2007.
H_2S Certification, 2014; OSHA 10-hour Hazard Recognition Training, 2013; Well Control Training, Workover and Completion, 2015.

Research and Professional Experience

August 2015–Present: Senior Operations Specialist, EERC, UND. Mr. Jacobson's responsibilities include leading field activities for the EERC related to drilling, logging, coring, and completion. He also analyzes hydraulic fracturing practices and conducts oil and gas pipeline evaluations and inspections in conjunction with EERC oilfield projects. In addition, Mr. Jacobson performs economic evaluations (e.g., cost–benefit analysis) of projects. Mr. Jacobson's principal areas of interest and expertise include optimizing wellsite layout for well servicing/completions, hydraulic fracturing techniques, logistics, field implementation planning, site management, and economic cost–benefit analysis of projects.

2007–2015: Operation Manager/Consultant, Bonetraill Rentals, LLC, Williston, North Dakota. Mr. Jacobson's responsibilities included hydraulic fracturing procedures, workover operations, completions, drilling operations, coil tubing, wireline, installation, independent third-party inspection of gas and production water pipelines, invoicing, daily reports, and overseeing other consultants for an oilfield service company that provides services to some of the largest oilfield operations in the Williston Basin region.

Mr. Jacobson took projects from concept through to production. He worked as a site manager for over 100 workover operations and has experience working in multiple formations, including the Bakken/Three Forks, Midale, Spearfish, Dakota, Red River, and Mission Canyon. He also has experience in the completion of produced-water disposal wells in the state of North Dakota. Mr. Jacobson typically managed health, safety, and environment (HSE) during all operations, except in extreme sour/H_2S environments. Specific site management projects included the following:

- Site Manager, Sundance Energy, Inc., which included site acquisition; site management during site preparation, drilling, completion (hydraulic fracturing, drill outs/cleanouts), and flow testing; site facilities and equipment installation; daily reporting; and site restoration.

- Site Manager, Cornerstone Natural Resources, LLC, which included site management during completion (hydraulic fracturing, drillout/cleanouts), flow testing, site facilities and equipment installation, and daily reporting.

- Site Manager, Crescent Point Energy US Corporation, which included site management during completion (hydraulic fracturing, drillout/cleanouts), flow testing, and daily reporting.

Site management for these projects also included controlling site access, serving as first point of contact for on-site contractors performing work, coordinating on-site activities among all on-site contractors, scheduling equipment deliveries and services, participating in daily phone conferences, ensuring maintenance/snow removal of pad and access roads, arranging fueling services, managing on-site analysis of fluids, arranging and managing off-site analysis of fluids, and scheduling and supervising water hauling and proper disposal of fluids. Mr. Jacobson was in charge of all scheduling and work performed

on-site during well activities, ensuring all testing/ work did not impact/damage the formation or future testing procedures.

2010–2011: Shop Supervisor, R&M Energy Systems, Oklahoma City, Oklahoma. Mr. Jacobson's responsibilities included manufacturing of sucker rod guides, overseeing a small work staff, maintenance of machinery, inventory, orders from different companies, and quality control procedures. Maintained the second-best profit margin in the company within the first year of operations.

2006–2006: Consultant, Bonetraill Rentals, LLC, Williston, North Dakota. Mr. Jacobson's responsibilities included hydraulic fracturing procedures, workover operations, drilling operations, daily reports, and invoicing.

Publications[1]

Hamling, J.A., Klapperich, R.J., Stepan, D.J., Sorensen, J.A., Pekot, L.J., Peck, W.D., Jacobson, L.L., Bosshart, N.W., Hurley, J.P., Wilson IV, W.I., Kurz, M.D., Burnison, S.A., Salako, O., Musich, M.A., Botnen, B.W., Kalenze, N.S., Ayash, S.C., Ge, J., Jiang, T., Dalkhaa, C., Oster, B.S., Peterson, K.J., Feole, I.K., Gorecki, C.D., and Steadman, E.N., 2016, Field implementation plan for a Williston Basin brine extraction and storage test: Phase I topical report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0026160, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Synergistic Activities

- Designed site infrastructure equipment and layout.
- Aided in design of drilling and completions plans.
- Aided in design of MVA activities.
- Aided in design of coring/logging program.
- Preparation of applications for permit to drill (APD), which entailed a drilling prognosis, casing schedule, cement schedule, and geological horizons, working closely with the North Dakota Industrial Commission to meet or exceed the required guidelines.

[1] Confidential, proprietary, and interim materials have not been included in this list.

STEVEN A. SMITH
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Education and Training
B.S., Geology, University of North Dakota, 2001.

Research and Professional Experience
2010–Present: Senior Geologist, AGL Team Lead, EERC, UND. Mr. Smith is currently working with a multidisciplinary team collaborating on research activities devoted to furthering our understanding of the subsurface geological environment. He is currently managing the Applied Geology Laboratory (AGL), which is actively pursuing research into the derivation of the physical properties of rocks and encompasses the disciplines of petrophysics, geochemistry, and geomechanics. The primary focus of the laboratory is the oil and gas industry and carbon capture and storage marketplace.

2004–2010: Research Scientist, EERC, UND. Mr. Smith's responsibilities included developing and implementing a work plan for acid gas monitoring, verification, and accounting (MVA) for the Zama acid gas disposal and enhanced oil recovery (EOR) project in Alberta; coordinating engineering, geological, geomechanical, and geochemical characterization activities for the Zama project; developing and maintaining a database of oil-bearing geologic reservoir characteristics as they pertain to CO_2 storage in the states and provinces of the Plains CO_2 Reduction (PCOR) Partnership region; evaluating saline aquifer systems and determining their potential for CO_2 sequestration; and developing estimates of the CO_2 storage capacity within oil-bearing and saline strata of the Williston, Alberta, Powder River, and Denver–Julesberg Basins. He also worked as a well site geologist in the Williston Basin.

2001–2003: Well Site Geologist, Subcontractor, Baker, Montana. Mr. Smith's responsibilities included overseeing all of the oil company's interests, with respect to the geologic decisions on location; preparing morning report and geologic strip logs to summarize well progression; directing interaction with oil company upper management; evaluating sample cuttings, gas, and drill times while project well was drilling; performing structural geologic correlation with offset wells; and working in close communication with directional driller and rig crew to maintain accuracy in completion of well.

1994: Staff Geologist Intern, R.E. Wight Associates, Inc., Middletown, Pennsylvania. Mr. Smith's responsibilities included system checks and operation at groundwater remediation sites, hazardous materials sampling and preparation, well purging, sampling, and recharge calculations.

Publications
Braunberger, J.R., Klapperich, R.J., Mibeck, B.A.F., Eylands, K.E., Huffman, B.W., Bremer, J.M., Bailey, T.P., Heebink, L.V., and Smith, S.A., 2013, Petrophysical assessment of USGS core samples for the Bell Creek project: Plains CO_2 Reduction (PCOR) Partnership value-added report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592 and the U.S. Geological Survey Core Research Center, Grand Forks, North Dakota, Energy & Environmental Research Center, November 2013.

Galbreath, K.C., Laumb, J.D., McCollor, D.P., Peck, W.D., Thompson, J.S., Kurz, B.A., Klenner, R.C.L., Smith, S.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Geochemical evaluation of the basal Cambrian system: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 16 Deliverable D89 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-11-11, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

LaBonte, J.L., Heebink, L.V., Lindeman, C.D., Klapperich, R.J., Bremer, J.M., Azenkeng, A., Eylands, K.E., Mibeck, B.A.F., and Smith, S.A., 2013, Characterization of Icebox, Deadwood, and Black Island Formation samples: Report for Energy & Environmental Research Center, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

Kurz, B.A., Schmidt, D.D., Smith, S.A., Beddoe, C.J., Lindeman, C.D., and Mibeck, B.A.F., 2012, Investigation of improved conductivity and proppant applications in the Bakken Formation: Final report (May 1, 2011 – April 30, 2012) for North Dakota Industrial Commission, EERC Publication 2012-EERC-08-04, Grand Forks, North Dakota, Energy & Environmental Research Center, August.Smith, S.A., 2012, Core analysis basics workshop – an integrated approach to core characterization: Presented at the Plains CO_2 Reduction (PCOR) Partnership Annual Meeting Core Analysis Basics Workshop, Milwaukee, WI, Sept 11, 2012.

Smith, S.A., Lindeman, C.D., LaBonte, J.L., Bremer, J.M., Azenkeng, A., Eylands, K.E., Mibeck, B.A.F., and Huffman, B.W., 2012, Analysis of rock samples from Clark Farms Well 29-10, Roosevelt County, Montana: Final report for Fort Worth Operating Company, LLC, EERC Publication 2012-EERC-10-01, Grand Forks, North Dakota, Energy & Environmental Research Center, October.

Sorensen, J.A., Kurz, B.A., Wocken, C.A., Smith, S.A., and Harju, J.A., 2012, Benchmarking, geomechanics, frac water & gas utilization—critical applied research. Presented at the 20th Williston Basin Petroleum Conference, Bismarck, North Dakota, May 22–24, 2012.

Smith, S.A., Azenkeng, A., Mibeck, B.A.F., Hurley, J.P., Eylands, K.E., Sorensen, J.A., and Harju, J.A., 2011, Subtask 1.5 – development of advanced reservoir characterization techniques: Final report (June 15, 2010 – June 30, 2011) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement DE-FC26-08NT43291, EERC Publication 2011-EERC-06-23, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Smith, S.A., Bremer, J.M., Mibeck, B.A.F., Lindeman, C.D., and Huffman, B.W., 2011, Characterization of samples from the Cretaceous age Second White Specks Formation: Final Report for Graham Davies Geological Consultants (CDGC) Ltd., EERC Publication 2011-EERC-12-06, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Smith, S.A., Sorensen, J.A., Steadman, E.N., Harju, J.A., and Ryan, D., 2011, Zama acid gas EOR, CO_2 sequestration, and monitoring project: Energy Procedia, v. 4, p. 3957–3964.

Synergistic Activities

- Member, Society of Petroleum Engineers
- Working with development and execution of laboratory based research to better address challenges associated with CO_2 storage and EOR projects.

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Education and Training

M.S., Exploration Geophysics, Stanford University, 1989; B.S., Geological Engineering, University of Minnesota, 1981

Research and Professional Experience

2012–Present: Principal Geophysicist, Geophysics Team Lead, EERC, UND. Responsibilities include interpretation of 3-D seismic data, geophysical modeling of the subsurface, processing of geophysical field data, petrophysical analyses of well log data, regional geological characterizations for oil and gas development and geologic CO_2 storage, and preparation of technical reports and proposals. Areas of expertise include the application of geophysics and well-logging principles to the efficient development of unconventional petroleum reservoirs and the application of geophysical methods for monitoring, verification, and accounting in CO_2 storage and enhanced oil recovery (EOR) operations. Currently serves as co-principal investigator (PI) for a scalable, automated, semipermanent seismic array (SASSA) project that uses the seismic method in an unconventional manner to track subsurface CO_2 plume migration and as PI on a project to investigate CO_2 plume migration using the Krauklis wave.
2010–2011: Project Controls/Earned Value Consultant, SLAC National Accelerator Laboratory. Assisted in preparing schedule and cost estimate for the "Linac Coherent Light Source – II" project, a $400M addition to the world's brightest hard x-ray laser, using Primavera P6 and costing using Deltek COBRA.
2007–2010: Senior Scientist – Program Management, NSTec. Maintained and improved the Nevada Test Site Environmental Management Program Risk Management Plan, identifying risks and computing impacts using Oracle Primavera Risk Analysis Monte Carlo software. Designed and updated monthly project metrics for senior management and posted project financial/schedule data to the federal project management system.
2005–2007: Field Lead – Environmental Restoration, NSTec. Planned, coordinated, and directed field activities and was OSHA supervisor under 40 CFR 1910 and 830, with 40-hr HAZWOPER credentials.
2003–2005: Task Manager – Environmental Restoration, Bechtel, Nevada. Managed projects, tracked earned value, and managed compliance at Nevada Test Site for Environmental Restoration Project for over 20 postclosure sites.
2002–2003: Contract Auditor/Logistics Analyst, Innovative Logistics, Inc., McLean, Virginia. Performed reconciliations and financial analyses at the direction of the CFO, employing Excel, Access, Deltek GCS, and Cognos Impromptu tools, working independently in support of a large government contract closeout; created reports for in-house clientele using Business Intelligence tools to enhance analysis; and worked shifts on a team on a 24/7 operation to produce a crucial daily deliverable report and management tool.
1994–2001: Investment Manager, Bali, Indonesia/Alexandria, Virginia. Managed personal portfolios of stock investments and controlled costs, taxes, and market actions with financial management software.
1996: Consulting Geophysicist, Robertson Research International, Islamabad, Pakistan. Initiated client relationships in Pakistan for an embryonic technical joint venture between British and Pakistani geophysical processing companies, trained local technical staff in digital processing theory, and designed and implemented production procedures for a start-up seismic data-processing center.
1992–1994: Geophysicist – Data Processing and Special Projects, Halliburton Geophysical Services, Jakarta, Indonesia. Served as a geophysical guru for local office staffed with expatriate and Indonesian professionals serving national and major oil company clientele, performing wavelet analysis, designing filters, establishing parameters for key projects, performing exotic processing–seismic inversions and prestack depth migrations, and designing land and marine 3-D seismic surveys to meet bid specifications.
1989–1992: Geophysicist – Data Processing and Data Collection, Halliburton Geophysical Services, Beijing and Ningxia Province, PRC. Worked for a local office staffed with expatriate and Chinese professionals, ensuring the quality of geophysical data processing and data collection for a remote joint venture computing center and Gobi desert-based data collection crew, establishing data collection

parameters based on modeling and field testing, designing data-processing procedures, and training Chinese technical staff.

1981–1987: General Field Engineer – Openhole Well-Logging and Borehole Seismic Specialist, Schlumberger Well Services, Sacramento and Bakersfield, California. Performed openhole wireline logging on over 200 oil and gas wells in California and other states. Directly responsible for the safety and performance of a three-man crew and a million-dollar mobile wireline unit and ensured regulatory compliance, handling and transporting explosive and radioactive materials. Specialized in borehole seismic methods, including vertical seismic profiles on land and sea.

Publications

Burnison, S.A., Burton-Kelly, M.E., Zhang, X., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Bell Creek test site – 3-D seismic and characterization report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Deliverable D96 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-04-04, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Burnison, S.A., Beddoe, C.J., Glazewski, K.A., Salako, O., Hamling, J.A., Ayash, S.C., and Gorecki, C.D., 2015, Technical design of a scalable, automated, semipermanent seismic array (SASSA) method for detecting CO_2 extent during geologic CO_2 injection: Deliverable D2 Interim Report on Completion of Technical Design (Oct 1, 2013 – Oct 31, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0012665, Grand Forks, North Dakota, Energy & Environmental Research Center, October 2015.

Burnison, S.A., Ditty, P., Gorecki, C.D., Hamling, J.A., Steadman, E.N., and Harju, J.A., 2013, Integrated geophysical monitoring program to study flood performance and incidental CO_2 storage associated with a CO_2 EOR project in the Bell Creek oil field: Presented at the American Geophysical Union Fall Meeting, San Francisco, California, December 9–13, 2013.

Kalenze, N.S., Hamling, J.A., Klapperich, R.J., Braunberger, J.R., Burnison, S.A., Glazewski, K.A., Stepan, D.J., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Bell Creek test site – site characterization report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Deliverable D64 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-02-15, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

Synergistic Activities

- PI on a $3 million DOE project, “Scalable, Automated, Semipermanent Seismic Method for Detecting CO_2 Plume Extent During Geological CO_2 Injection,” including directing day-to-day operations, budget management, modeling, data management, and reporting.
- PI on a $2.5 million DOE project, “Field Demonstration of the Krauklis Seismic Wave in a Novel MVA Method for Geologic CO_2 Storage,” including directing day-to-day operations, budget management, data management, and reporting.
- Subtask lead on a $3 million DOE project, “Development of Intelligent Monitoring System (IMS) Modules for the Aquistore CO_2 Storage Project,” including three subtasks on integrating seismic data into the IMS system.
- Manage collection/processing/interpretation/analysis of data collected by PCOR Partnership borehole seismic array, a 50-level, 200-channel array cemented vertically into the 04-03 OW well at Bell Creek Field, which has acquired passive microseismic data since installation (April 2013) as part of MVA activities at Bell Creek.
- Oversee survey design/data collection/data processing of three 3-D vertical seismic profiles collected at Bell Creek for PCOR Partnership including 4-D interpretation/analysis of processed data.
- Manage EERC interpretation/4-D analysis of two 3-D surface seismic monitor surveys acquired in partnership with Denbury at Bell Creek Field to characterize CO_2 storage for PCOR Partnership.

NICHOLAS W. BOSSHART
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Energy & Environmental Research Center (EERC), University of North Dakota (UND)
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Education and Training

M.S., Geology, University of North Dakota, 2014.
B.S., Geology, University of Northern Iowa, 2012.
Proficient in the use of Microsoft Office Suite, ArcGIS: ArcMap, Surfer, Petra, Petrel, Neuralog, CMG, and JewelSuite.

Research and Professional Experience

June 2014–Present: Senior Geologist, Geomodeling Team Lead, EERC, UND. Mr. Bosshart's responsibilities include developing geophysical reservoir models for hydrocarbon resource assessment and geologic CO_2 storage analyses. Mr. Bosshart's principal areas of interest and expertise include well log, core, and thin-section petrophysical analysis; geologic characterization and data management; geostatistical applications; geocellular reservoir modeling; enhanced oil recovery (EOR) utilizing CO_2; and geologic storage of CO_2.

2013–June 2014: Graduate Student Research Assistant, EERC, UND. Mr. Bosshart's responsibilities included CO_2 geologic storage modeling, Petra software projects, and Petrel software-based 3-D modeling.

2013: Internship, EERC, UND. Mr. Bosshart's responsibilities included CO_2 geologic storage modeling, Petra software projects, Petrel software-based 3-D modeling, and over 120 hours of software and geostatistics training.

May–June 2013: Graduate Student Teaching Assistant, South Dakota School of Mines and Technology, Annapurna Region, Himalayas, Nepal. Mr. Bosshart was a graduate student teaching assistant for geologic field studies of the Himalayas. His responsibilities included identification and mapping of metamorphic rocks associated with the Main Central Thrust Zone of the Himalayas, mapping and developing reports discussing active geomorphic agents in the region, and mapping of glacial sediments.

August 2012−May 2013: Graduate Student Teaching Assistant, Harold Hamm School of Geology and Geologic Engineering, UND. Mr. Bosshart instructed introductory geology laboratory courses.
2006–2014: Unit Supply Specialist, Iowa National Guard, United States Army, Camp Dodge, Johnston, Iowa.

Publications

Hamling, J.A., Klapperich, R.J., Stepan, D.J., Sorensen, J.A., Pekot, L.J., Peck, W.D., Jacobson, L.L., Bosshart, N.W., Hurley, J.P., Wilson IV, W.I., Kurz, M.D., Burnison, S.A., Salako, O., Musich, M.A., Botnen, B.W., Kalenze, N.S., Ayash, S.C., Ge, J., Jiang, T., Dalkhaa, C., Oster, B.S., Peterson, K.J., Feole, I.K., Gorecki, C.D., and Steadman, E.N., 2016, Field implementation plan for a Williston Basin brine extraction and storage test: Phase I topical report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0026160, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Jin, L., Sorensen, J.A., Hawthorne, S.B., Smith, S.A., Bosshart, N.W., Burton-Kelly, M.E., Miller, D.J., and Grabanski, C.B., 2016, Improving oil transportability using CO_2 in the Bakken system – a laboratory investigation: Presented at the SPE International Conference & Exhibition on Formation Damage Control, Lafayette, Louisiana, February 24–26, 2016, SPE-178948-MS.

Bosshart, N.W., Braunberger, J.R., Burton-Kelly, M., Dotzenrod, N.W., and Gorecki, C.D., 2015, Multiscale reservoir modeling for CO_2 storage and enhanced oil recovery using multiple point statistics: Poster presented at the EAGE Petroleum Geostatistics 2015 Conference, Biarritz, France, September 7–11, 2015.

Braunberger, J.R., Bosshart, N.W., Klenner, R.C.L., Liu, G., Peck, W.D., and Gorecki, C.D., 2014, Characterization and 3-D modeling of Devonian pinnacle reefs for CO_2 storage and enhanced oil recovery: Presented at the 2014 Rocky Mountain Section AAPG Annual Meeting, Denver, Colorado, July 20–22, 2014.

Klenner, R.C.L., Braunberger, J.R., Dotzenrod, N.W., Bosshart, N.W., Peck, W.D., and Gorecki, C.D., 2014, Training image characterization and multipoint statistical modeling of clastic and carbonate formations: Presented at the 2014 Rocky Mountain Section AAPG Annual Meeting, Denver, Colorado, July 20–22, 2014.

Synergistic Activities

- Currently involved in multiple DOE-funded projects involving modeling and numerical simulation efforts aimed at increasing our understanding of CO_2 storage, residual oil zones and CO_2 EOR; CO_2 storage efficiency, brine extraction for reservoir pressure management, risks associated with CO_2 storage and management of these risks through existing and novel monitoring, verification, and accounting activities; and determining the long-term fate of injected CO_2.
- Member, American Association of Petroleum Geologists (AAPG), European Association of Geoscientists (EAGE), and Geological Society of America (GSA)
- Technical reviewer, International Journal of Greenhouse Gas Control
- Presenter at technical conferences, including 2015 EAGE Petroleum Geostatistics, 2015 Annual CCUS, 2014 AAPG Rocky Mountain Section, and 2010–2012 national GSA conferences.

LAWRENCE J. PEKOT
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Education and Training

B.S., Civil Engineering, Pennsylvania State University, 1978.
B.S., Geological Science, Pennsylvania State University, 1978.

Research and Professional Experience

September 2015–Present: Principal Engineer, Reservoir Engineering Group Lead, EERC, UND. Mr. Pekot's responsibilities include:

- Leading reservoir engineering evaluations for CO_2 enhanced oil recovery (EOR), CO_2 storage, and unconventional hydrocarbon recovery projects.
- Leading a group of reservoir engineers on multiphase flow, geomechanical, thermal, and geochemical interaction simulations.

2008–2015: International Project Manager, Schlumberger Carbon Services, Denver, Colorado, and Paris, France.

- Management and technical oversight of carbon storage evaluation projects and opportunities in Europe and Africa, including work in the United Kingdom, Ireland, Spain, Italy, Poland, Romania, Bulgaria, Libya, South Africa, and Australia.
- Supervision of site selection studies, simulation, appraisal planning, risk analysis, injection testing and monitoring technologies, regulatory compliance, cost estimation, and reporting.
- Supervision and mentoring of junior staff.

2004–2007: Principal Consultant, Schlumberger Data and Consulting Services, Pittsburgh, Pennsylvania.

- Engineering studies for tight gas, gas storage, shale, and CBM properties in the United States and Canada, including reserve reporting evaluations for conventional, coalbed methane (CBM), and CO_2 flood properties.
- EOR CO_2 flood evaluations of Michigan Basin pinnacle reef reservoirs.

1995–2003: Vice President, Advanced Resources International, Inc., Washington, D.C.

- Development, maintenance, and marketing of the firm's unconventional reservoir simulator, COMET.
- Reservoir engineering advisor for the U.S. Federal Energy Regulatory Commission.
- Performing or supervising well testing and numerical simulation evaluations of numerous gas, oil, gas storage, CBM, enhanced coalbed methane (ECBM), and other unconventional reservoirs, including projects in Australia, Canada, China, Czech Republic, India, Poland, South Africa, and the United States.
- ECBM and shale gas simulation.
- Estimated reserves for merger and acquisition economic evaluations.
- Field demonstration of advanced simulation technologies for gas storage wells.
- Well testing and evaluation methodologies for gas storage remediation candidate selection.

1991–1995: Principal Consultant, Scandpower A/S (now SPT Group of Schlumberger), Oslo, Norway

- Supervision and mentoring of a team of four engineering consultants.
- Consulting assignments for PEMEX (Mexico), Norsk Hydro, Saga Petroleum.

1978–1991: Senior Petroleum Engineer, Phillips Petroleum Company, Stavanger, Norway, and Houston, Texas.

- Senior Joint Venture Engineer for Gulf of Mexico properties (3 years), including profit and loss accountability for a $20 million capital and expense budget. Technical, economic, and reserves evaluations.
- Senior Engineer (4 years), including supervision of a team of engineers for numerical simulation of North Sea oil and gas fields; drilling and workover proposal justifications; economic analysis; reservoir management plan maintenance and updates; evaluation of oil and gas reserves.
- Associate Production Geologist (2 years), including wellsite geology; correlating geological and geophysical data and creating maps and cross sections, geological field studies.
- Staff Reservoir Engineer (3 years), wellsite testing and analysis of new gas production wells, well test analysis and selection of new drilling locations, evaluation of field production problems.
- General land-based production (1 year), including EOR projects, drilling, and workover operations,

Professional Affiliations

Member, Society of Petroleum Engineers. Distinguished Lecture Review Committee, 2006–2011
Technical Reviewer, *International Journal of Coal Geology*

Publications

Gendrin, A., Zen, D., Sosio, G., Pekot, L.J., Andres, R., Gonzalez, P., Gimenez, A., and Ballesteros, J.C., 2013, Seismic interpretation for carbon dioxide geologic storage—Duero Basin, Spain: European Association of Geoscientists and Engineers 75th Conference & Exhibition, London, June 10–13.

Gendrin, A., Pekot, L.J., Mat Fiah, N., and Garnett, A., 2012, Feasibility study for using 2-D surface seismic surveys as a monitoring tool for large-scale CO_2 storage in the Gippsland Basin, Victoria, Australia: Presented at GHGT-11 Conference, Kyoto, Japan, November 18–22, paper no. 1094.00.

Pekot, L.J., Petit, P., Adushita, Y., Saunier, S., and DeSilva, R., 2011, Simulation of two-phase flow in carbon dioxide injection wells: Society of Petroleum Engineers (SPE) Offshore Europe Conference, Aberdeen, United Kingdom, September 6–8, SPE 144847.

Pamukcu, Y., Hurter, S., Jammes, L., Vu-Hoang, D., and Pekot, L., 2011, Characterizing and predicting short-term performance for the In Salah Krechba Field CCS joint industry project: Presented at GHGT-10 Conference, Amsterdam, Netherlands, September 19–23, 2010, Energy Procedia, v. 4, p. 3371–3378.

Pekot, L.J., 2009, Session 8—monitoring and modeling: Presentation and discussion leader, Society of Petroleum Engineers Forum – CO_2 Capture and Storage, Cadiz, Spain, September 13–18.

Kuuskraa, V.A., and Pekot, L.J., 2002, Defining optimum carbon dioxide sequestration sites for power and industrial plants: 6th International Conference on Greenhouse Gas Control Technologies, Kyoto, Japan, October.

Reeves, S.R., Pekot, L.J., et al., 1999, Gas storage deliverability enhancement: Oil & Gas Journal, four-part series, November 15 – December 20, Tulsa, Oklahoma, Pennwell.

Synergistic Activities

- Member, Society of Petroleum Engineers Distinguished Lecture Review Committee, 2006–2011
- Technical Reviewer, *International Journal of Coal Geology*

DANIEL J. DALY
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Education and Training

M.S., Geology, University of North Dakota, 1984.
B.A., Earth Science, New Mexico Highlands University, 1974.

Research and Professional Experience

1975–Present: Senior Geologist/Public Outreach Specialist, Outreach Team Lead, EERC, UND. During his tenure at the EERC, Mr. Daly has served in the following specific roles:

2003–Present: Manager, Outreach and Education, Plains CO_2 Reduction (PCOR) Partnership (Clients: U.S. Department of Energy [DOE] and more than 80 government and industry stakeholders in the United States and Canada).

1999–2008: Coordinator, Red River Valley Clean Cities Coalition (Clients: U.S. Department of Agriculture, DOE, and regional stakeholders).

2000–2003: Project Manager, Red River Geoscience Education Pilot Project (Client: National Science Foundation).

2001–2004: Task Manager, Red River Environmental Information Network (Client: U.S. Environmental Protection Agency).

1995–2003: Management Team Member, DOE Environmental Management Program (Cooperative Agreement providing technical support for the development of innovative technologies to aid in nuclear complex cleanup; Client: DOE).

1992–1995: Task Manager, national-level assessment of waste generation and shallow subsurface environmental issues related to gas industry exploration and production (Clients: GTI and DOE).

1989–1998: Task Manager, tracking and assessment of government policy and regulatory actions in support of strategic planning for the EERC.

In addition, Mr. Daly also served as a technician on several project-based appointments with the North Dakota Geological Survey, UND's North Dakota Mining and Mineral Resources Research Institute, and UND's Engineering Experiment Station.

Publications

Crocker, C.R., Crossland, J.L., Chimote, S.A., Daly, D.J., Anagnost, K.K., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2016, Public Web site updates: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D13 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2014-EERC-09-06, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Daly, D.J., Crocker, C.R., Steadman, E.N., and Harju, J.A., 2016, Outreach action plan: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D11 Update 2 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2011-EERC-03-06, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Daly, D.J., Crocker, C.R., Hamling, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2015, CO_2 emissions go to work to produce more oil: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D25 poster (update 1) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

Gorecki, C.D., Daly, D.J., Crocker, C.R., Crossland, J.L., Steadman, E.N., and Harju, J.A., 2015, PCOR Partnership outreach – over a decade of activity: Presented at the 10th CO_2GeoNet Open Forum, San Servolo Island, Venice, Italy, May 11–12, 2015.

Daly, D.J., and Crocker, C.R., 2014, Energy and carbon—the big picture: Presented at Cultivating Geographic Connections in the Red River Valley: A Crossroads of Agriculture, Reinvention, and Innovation – Minnesota Alliance for Geographic Education and the North Dakota Geography Alliance, Moorhead, Minnesota, June 18, 2014.

Daly, D.J., Crocker, C.R., Crossland, J.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Regional and project-based CCUS outreach – the PCOR Partnership experience: Poster presented at the 2014 IEAGHG Social Research Network Annual Meeting, Calgary, Alberta, January 14–15, 2014.

Wade, S., Cather, M., Cumming, L., Daly, D.J., Garrett, G., Greenberg, S., Myhre, R., Stone, M., and Tollefson, L., 2014, Digital communications—status and potential applications for CCUS public outreach: Energy Procedia, v. 63, p. 7070–7086.

Daly, D.J., and Wade, S., 2012, Message mapping for CCUS outreach—testing communications through focus group discussion: Paper presented at the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11), Kyoto, Japan, November 18–22, 2012.

Daly, D.J., Bradbury, J., Garrett, G., Greenberg, S., Myhre, R., Peterson, T., Tollefson, L., Wade, S., and Sacuta, N., 2011, Outreach best practices—a practical foundation for the future: Poster presented at the SPE International Forum: CO_2 Geological Storage: Will We Be Ready in Time?, Faro, Portugal, October 7–14, 2011.

Hanson, S.K., Daly, D.J., Steadman, E.N., and Harju, J.A., 2004, Carbon sequestration – A community focus group study of attitudes in Williston, North Dakota; Plains CO_2 Reduction (PCOR) Partnership topical report for U.S. Department of Energy and multiclients, Grand Forks, ND, Energy & Environmental Research Center, June 2005.

Synergistic Activities

- Associate Producer and Coauthor for five carbon capture and storage-related public television documentaries—*Nature in the Balance: CO_2 Sequestration*, *Reducing Our Carbon Footprint: The Role of Markets*, *Out of the Air – Into the Soil: Land Practices That Reduce Atmospheric Carbon Levels*, Managing *Carbon Dioxide: The Geologic Solution*, and *Global Energy and Carbon: Tracking Our Footprint* —and two other documentaries that are currently in production.
- Member, DOE Regional Carbon Sequestration Partnership Initiative Outreach Working Group (2003 to present).
- Member, Aquistore CO_2 Storage Project Outreach Advisory Group (2011 to present).
- Member, IEA Greenhouse Gas R&D Programme (IEAGHG) Weyburn–Midale CO_2 Monitoring and Storage Project Outreach Advisory Panel (2008 to 2011).

BARRY W. BOTNEN
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Education and Training

B.S., Environmental Geology and Technology, University of North Dakota, 1994.

Research and Professional Experience

2001–Present: Hydrogeologist, Oilfield Operations, EERC, UND. Supports multiple activities of the Plains CO_2 Reduction (PCOR) Partnership, a three-phase, multiyear, multimillion-dollar program to assess the technical and economic feasibility of capturing and storing CO_2 emissions from stationary sources in the northern Great Plains and adjacent area. Develops and implements monitoring, verification, and accounting (MVA) concepts for large-scale (>1 million tons per year) CO_2 storage and enhanced oil recovery (EOR) operations. Served as task lead for Terrestrial Field Validation Test. Has over 20 years of experience in the design and construction of groundwater and soil remediation systems as well as CO_2 sequestration/storage, contaminated site assessment, contaminant release investigation, remedial design/action, wetlands identification/delineation, biota studies, and the stewardship of contaminated nuclear sites. Has performed numerous subsurface site investigations relating to hazardous wastes and completed many Phase I and II site assessments as well as Phase III cleanup activities.

1996–2001: Associate Geologist, OASIS Environmental, Inc., Anchorage, Alaska. Responsibilities included the following:

- Project manager for Alaska Railroad Corp. site assessment to identify remedial alternatives.
- Remedial investigations at King Salmon Air Force Base, and Elmendorf Air Force Base, Alaska, as part of a staff augmentation with Radian International Inc. and Jacobs Engineering.
- Wetland identifications/delineations for remote natural gas drilling operations.
- Determination of wetland areas to be permitted for access roads and drill pad construction along the western edge of Cook Inlet.
- Project manager for a Tesoro, Alaska, release investigation, including installing and sampling groundwater-monitoring wells and soil borings, oversight of remedial design using soil vapor extraction (SVE) and AS techniques.
- Quality assurance supervisor for construction of a fuel pipeline traversing the coastal mudflats from the Port of Anchorage to the Anchorage International Airport.
- Field geologist for Elmendorf Air Force Base pipeline release assessment and projects at King Salmon Airport, including field supervision of contaminated site excavation, sampling in a support of wetland and human food chain pathway evaluation, wetland revegetation, costing a project proposal for a postclosure monitoring program, and fieldwork and administrative tasks for a treatability study.
- Excavation of the Trans-Alaska Pipeline System (TAPS) in Thompson Pass near Valdez, Alaska.
- Site assessment and remedial action in Valdez involving a diesel release at Robe River Pumphouse.
- Environmental site assessments at four former construction camps along the TAPS.
- Wetlands delineation project at Fort Richardson, Alaska.
- Wetlands delineation and biota sampling project at King Salmon Airport.

Publications

Hamling, J.A., Klapperich, R.J., Stepan, D.J., Sorensen, J.A., Pekot, L.J., Peck, W.D., Jacobson, L.L., Bosshart, N.W., Hurley, J.P., Wilson IV, W.I., Kurz, M.D., Burnison, S.A., Salako, O., Musich, M.A., Botnen, B.W., Kalenze, N.S., Ayash, S.C., Ge, J., Jiang, T., Dalkhaa, C., Oster, B.S., Peterson, K.J., Feole, I.K., Gorecki, C.D., and Steadman, E.N., 2016, Field implementation plan for a Williston Basin

brine extraction and storage test: Phase I topical report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0026160, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Hamling, J.A., Stepan, D.J., Kalenze, N.S., Klapperich, R.J., Botnen, B.W., and Leroux, K.M., 2013, Baseline soil gas monitoring at the Bell Creek combined CO_2 enhanced oil recovery and CO_2 storage project: Poster presented at the Carbon Management Technology Conference, Alexandria, Virginia, October 21–23.

Botnen, B.W., Klapperich, R.J., Gorecki, C.D., and Steadman, E.N., 2011, Bell Creek test site – hydrogeological experimental design package: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Deliverable D34 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2011-EERC-10-03, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Steadman, E.N., Anagnost, K.K., Botnen, B.W., Botnen, L.S., Daly, D.J., Gorecki, C.D., Harju, J.A., Jensen, M.D., Peck, W.D., Romuld, L., Smith, S.A., Sorensen, J.A., and Votava, T.J., 2011, The Plains CO_2 Reduction (PCOR) Partnership—developing carbon management options for the central interior of North America: Energy Procedia, v. 4, p. 6061–6068.

Cihacek, L.J., Botnen, B.W., and Steadman, E.N., 2010, A sampling protocol for monitoring, measurement, and verification of terrestrial carbon sequestration in soils: Value-added report for North Dakota State University, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Peck, W.D., Anagnost, K.K., Botnen, B.W., Botnen, L.S., Daly, D.J., Gorecki, C.D., Grove, M.M., Harju, J.A., Jensen, M.D., Jones, M.L., Smith, S.A., Sorensen, J.A., Steadman, E.N., Wolfe, S.L., McNemar, A.T., Litynski, J.T., and Plasynski, S.I., 2010, Plains CO_2 Reduction (PCOR) Partnership atlas (3d ed. rev.): Prepared for the U.S. Department of Energy National Energy Technology Laboratory and the PCOR Partnership, Grand Forks, North Dakota, Energy & Environmental Research Center, 65 p.

Botnen, B.W., Steadman, E.N., and Harju, J.A., 2009, Terrestrial carbon sequestration in the northern Great Plains: Presented at the Regional Carbon Sequestration Partnership (RCSP) Annual Review Meeting, Pittsburgh, Pennsylvania, November 16–19.

Peck, W.D., Anagnost, K.K., Botnen, B.W., Botnen, L.S., Daly, D.J., Gorecki, C.D., Grove, M.M., Harju, J.A., Jensen, M.D., Jones, M.L., Smith, S.A., Sorensen, J.A., Steadman, E.N., Wolfe, S.L., McNemar, A.T., Litynski, J.T., and Plasynski, S.I., 2009, Plains CO_2 Reduction (PCOR) Partnership atlas (3d ed.): Prepared for the U.S. Department of Energy National Energy Technology Laboratory and the PCOR Partnership, Grand Forks, North Dakota, Energy & Environmental Research Center, 65 p.

Renner, R., Dell, R., Browne, D., Gleason, R., Leistritz, L., Bangsund, D., Botnen, B.W., Ye, D., Steadman, E.N., and Harju, J.A., 2009, Deliverable D54 Task 5 – Terrestrial field validation test regional technology implementation plan: Phase II Final Report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Ducks Unlimited, North Dakota State University, and U.S. Geological Survey, EERC Publication 2010-EERC-02-04, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Steadman, E.N., Harju, J.A., Botnen, L.S., Daly, D.J., Jensen, M.D., Smith, S.A., Botnen, B.W., Sorensen, J.A., Peck, W.D., Wolfe, S.L., and Fischer, D.W., 2009, Plains CO_2 Reduction (PCOR) Partnership Phase II and III activities: Presented at the 8th Annual Conference on Carbon Capture and Sequestration, Pittsburgh, Pennsylvania, May 4–7.

Synergistic Activities

- Develops and implements MVA concepts for large-scale CO_2 storage and EOR operations.
- Served as task lead for Terrestrial Field Validation Test portion of the PCOR Partnership.
- Serves as hydrogeologist and primary landowner contact for Brine Extraction and Storage Test (BEST) project.
- Member, National Groundwater Association.

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Education and Training
B.S., Geology, University of North Dakota, 1991.
Postgraduate course work in Geology and Hydrogeology, 1993–1995.

Research and Professional Experience
1999–Present: Principal Geologist, EERC, UND. Mr. Sorensen currently serves as manager and co-principal investigator for several research programs, including the Plains CO_2 Reduction (PCOR) Partnership, a multiyear program focused on developing strategies for reducing carbon dioxide emissions in nine states and four Canadian provinces. He has also conducted projects to develop an improved understanding of the Bakken petroleum system, including efforts to examine the potential to use carbon dioxide for enhanced oil recovery in the Bakken. Responsibilities include supervision of research personnel, preparing and executing work plans, budget preparation and management, writing technical reports and papers, presentation of work plans and results at conferences and client meetings, and proposal writing and presentation. Mr. Sorensen's principal areas of interest and expertise include tight oil resource assessment and development, carbon dioxide utilization and storage in geologic formations, and environmental issues associated with the oil and gas industry.

1997–1999: Program Manager, EERC, UND. Mr. Sorensen managed projects on topics that included produced water management, environmental fate of natural gas-processing chemicals, coalbed methane, and gas methane hydrates.

1993–1997: Geologist, EERC, UND. Mr. Sorensen conducted a variety of field-based hydrogeologic investigations throughout the United States and Canada. Activities were primarily focused on the subsurface mobility of constituents associated with natural gas production sites.

1991–1993: Research Specialist, EERC, UND. Mr. Sorensen assembled and maintained comprehensive databases related to oil and gas drilling, production, and waste management.

Professional Memberships
Society of Petroleum Engineers

Publications
Sorensen, J.A., Jensen, M.D., Nelson, C.R., Smith, S.A., Fischer, D.W., Steadman, E.N., and Harju, J.A., 2005, Geologic sequestration potential of the PCOR Partnership region: Plains CO_2 Reduction (PCOR) Partnership Topical Report for U.S. Department of Energy and multiclients, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

Fischer, D.W., Smith, S.A., and Peck, W.D., LeFever, J.A., LeFever, R.D., Helms, L.D., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2004, Sequestration potential of the Madison of the Northern Great Plains aquifer system (Madison geological sequestration unit): Plains CO_2 Reduction (PCOR) Partnership topical report for U.S. Department of Energy and multiclients, Grand Forks, North Dakota, Energy & Environmental Research Center, October.

Sorensen, J.A., Smith, S.A., Fischer, D.W., Steadman, E.N., and Harju, J.A., 2005, Potential CO_2 storage capacity of the saline portions of the Lower Cretaceous Aquifer Systems in the PCOR Partnership

Region: Plains CO_2 Reduction (PCOR) Partnership Topical Report for U.S. Department of Energy and multiclients, Grand Forks, North Dakota, Energy & Environmental Research Center, October.
Sorensen, J.A., Bailey, T., Smith, S.A., Dobroskok, A.A., Fischer, D.W., Gorecki, C.D., Peck, W., and Harju, J.A., 2008, Characterization and modeling of the Brook Creek Formation for potential storage of CO_2 from coal-fired power plants in North Dakota: Topical report, Grand Forks, North Dakota, Energy & Environmental Research Center, March.
Sorensen, J.A., Botnen, L.S., Smith, S.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Application of Canadian Standards Association guidelines for geologic storage of CO_2 toward the development of a monitoring, verification, and accounting plan for a potential CCS project at Fort Nelson, British Columbia, Canada: Energy Procedia, v. 63, p. 5959–5970.
Gorecki, C.D., Liu, G., Bailey, T.P., Sorensen, J.A., Klapperich, R.J., Braunberger, J.R., Steadman, E.N., and Harju, J.A., 2013, The role of static and dynamic modeling in the Fort Nelson CCS Project: Energy Procedia, v. 37, p. 3733–3741.
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Synergistic Activities

- Task manager since 2003 for the PCOR Partnership, which has involved efforts to characterize geologic formations with respect to their potential to store CO_2 and field demonstrations of CO_2 storage, including characterizing the Lower Cretaceous and Mississippian Aquifer systems in Wyoming.
- Project manager and technical leader for efforts focused on characterization, modeling, risk assessment, and MVA planning for the Fort Nelson CCS Feasibility Study, which was conducted under the PCOR Partnership from 2009 to 2014.

The knowledge and experience gained from these efforts can be directly applied to the proposed work.

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Senior Reservoir Engineer – Unconventional Reservoirs
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Education and Training
Ph.D. (2008), Chemical and Process Engineering, Universitat Rovira i Virgili, Tarragona, Spain;
Reservoir Engineering Specialist (2002) and Chemical Engineer (1999), Universidad Simón Bolívar, Caracas, Venezuela

Research and Professional Experience
2016–Present: Senior Reservoir Engineer – Unconventional Reservoirs, Reservoir Engineering Group, EERC, UND. Work focuses on resolving the advanced challenges of unconventional reservoirs related to production mechanisms and CO_2 enhanced oil recovery (EOR) in tight reservoir rocks, CO_2 storage, high-volume brine disposal, and advanced reservoir-monitoring techniques. Duties include evaluating and interpreting geoscience and engineering data; using oil and gas industry simulation and other software packages to determine the long-term performance of subsurface reservoirs and the fate of produced/ injected fluids; recommending, assisting with, and preparing proposals to potential clients; and reporting results. Areas of expertise include aspects of reservoir engineering, such as reservoir simulation, production mechanisms and EOR for unconventional reservoirs, fluid flow in porous media, and thermodynamics of reservoir fluids, particularly the development of novel recovery processes and advanced reservoir-monitoring techniques.
2012–2015: Senior Reservoir Engineer/Technology Engineer, Conoco Phillips Company, Houston, Texas. Proposed and implemented two innovative and cost-effective solutions for technical problems found in the team's expertise area. Novel solutions were significantly more efficient and from 5 to 20 times more cost-effective than the other alternatives. Proposed and started three collaborative R&D projects with recognized external centers. Interpreted physical phenomena involved in the flow of fluids in porous media. Conceptualized mathematical models and designed algorithms for the evaluation of the production performance in unconventional reservoirs. Supported the reservoir engineering community on simulation studies for diverse applications, such as history match and optimization workflows, EOR projects, and coupled-flow geomechanics. Represented the company in joint industry projects. Mentored two summer intern projects. Advised junior and senior engineers on troubleshooting numerical issues found with their simulations. Disseminated knowledge within the company and delivered technical presentations to diverse audiences to share novel technologies.
2007–2011: Research Engineer, ADERA, Pessac, France. Performed studies to evaluate the feasibility of novel recovery processes for heavy oil reservoirs. Developed an innovative simulation tool to couple a finite-volume reservoir simulator with a finite element multiphysics simulator. Planned, implemented, and analyzed numerical models and simulations. Mentored four master's students during their summer internships. Prepared reports and presented results to the industrial advisor committee. Published research articles and represented the center in international conferences.
2003–2007: Ph.D. Candidate/Teaching Assistant, Universitat Rovira i Virgili, Tarragona, Spain. Developed, planned, and executed a project that delivered excellent end products in three different areas; designed and constructed a new laboratory-scale reactor, fully operative and tested by the project deadline; designed experiments and performed process simulations to evaluate equipment performance; started a collaboration with a recognized research group on catalyst development; mentored undergraduate students and trained a postdoctoral researcher; and taught practice in project management, thermodynamics, and chemical engineering lab.
2000–2003: Professional Engineer/Research Engineer, PDVSA-INTEVEP, Los Teques, Venezuela. Evaluated a streamline simulator for waterflooding in fractured reservoirs; developed a research

simulator, implementing new physical models for heavy oil production by solution gas drive; and history-matched lab experiments using the research code.
1999–2000: Junior Engineer, Vasquez y Vasquez Consultores, Caracas, Venezuela. Supported senior engineers on multiple consultancy and training projects.

Publications

Torres J.A., 2016, Development of Intelligent Monitoring System (IMS) Modules for the Aquistore CO_2 Storage Project: Presented at the 2016 Mastering the Subsurface Through Technology Innovation and Collaboration: Carbon Storage and Oil and Natural Gas Technologies Review Meeting, Pittsburgh, PA, August 16–18.

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Bogdanov, I.I., Torres, J.A., El Ganaoui, K., and Kamp, A.M., 2009, Feasibility of COMSOL coupling to reservoir simulator—electro-thermo-hydrodynamical model: Presented at the European COMSOL Conference 2009, Milan, Italy, October 14–16.

Synergistic Activities

- Technical leader of modeling and simulation tasks for DOE-sponsored project, "Development of Intelligent Monitoring System (IMS) Modules for the Aquistore CO_2 Storage Project," the objective of which is to develop new, real-time-data-capable workflows designed to automate the integration of CO_2 storage site-monitoring data within an IMS. In particular, will be improving history matching via integrating pressure, seismic, and injection data in order reduce uncertainty in pressure and saturation distributions, thereby allowing a site operator to optimize CO_2 storage performance, timing, and frequency of monitoring, verification, and accounting to better manage the storage project risk profile.
- Uses National Risk Assessment Partnership (NRAP) tools to complement modeling and simulation efforts for DOE-sponsored project, "Developing and Validating Pressure Management and Plume Control Strategies in the Williston Basin Through a Brine Extraction and Storage Test."
- Member, Society of Petroleum Engineers, American Institute of Chemical Engineers, and European Association of Geoscientists & Engineers.

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Education and Training
B.S., Geological Engineering, University of North Dakota, 2007.

Research and Professional Experience
2015–Present: Director of Subsurface R&D, EERC, UND. Mr. Gorecki is responsible for developing and managing programs and projects focused on conventional, unconventional, and enhanced oil and gas production; the geologic storage of CO_2; geothermal; and other energy and environmental research. He currently serves as the Program Manager for the Plains CO_2 Reduction (PCOR) Partnership, one of seven regional partnerships funded by the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory Regional Carbon Sequestration Partnership Program. The PCOR Partnership Program is a three-phase, multiyear, multimillion-dollar program, focused on assessing the technical and economic feasibility of capturing and storing CO_2 emissions from stationary sources in the northern Great Plains and adjacent area. Under this program, Mr. Gorecki leads a multidisciplinary team of researchers working primarily on developing monitoring, verification, and accounting concepts and technologies for large-scale CO_2 storage (>1 million tons per year) in deep saline formations and oil fields and the characterization of the geologic formations in the PCOR Partnership region in preparation for the implementation of the commercial deployment of carbon capture and storage (CCS). In addition to the PCOR Partnership Program, Mr. Gorecki also manages or oversees projects related to CO_2 storage capacity estimation, novel reservoir surveillance and CO_2 storage monitoring techniques, and unconventional oil and gas resource modeling, characterization, and testing. He has also led several other national and international projects associated with CO_2 storage, the nexus of water and CO_2, and CO_2 enhanced oil recovery (EOR).

2011–2015: Senior Research Manager, EERC, UND. Mr. Gorecki was the manager of the PCOR Partnership and the technical lead for the Bell Creek CO_2 EOR field demonstration. He led the geologic modeling and simulation efforts for the EERC as well as national and international efforts associated with the nexus of water and carbon capture and storage and efforts focused on developing storage capacity estimates and methodologies for deep saline formations and hydrocarbon reservoirs. In addition, Mr. Gorecki has led and worked on detailed site characterization, modeling, risk assessment, and monitoring activities for both EOR projects and CO_2 storage operations in deep saline formations. He participated in several expert review committees and was involved in developing a methodology for estimating CO_2 storage capacity in deep saline formations, oil and gas reservoirs, and shale formations for DOE.

2010–2011: Research Manager, EERC, UND. Mr. Gorecki led the modeling and monitoring and Water Working Group tasks for Phase III of the PCOR Partnership Program. He led the EERC's geologic modeling efforts, coordinating a multidisciplinary team to develop detailed geologic models and run predictive simulations for CO_2 storage, CO_2 EOR, and unconventional oil and gas plays. Mr. Gorecki was also the facilitator of the Regional Carbon Sequestration Partnership Water Working Group, where he led discussion on the nexus of water and carbon capture and storage.

2007–2010: Research Engineer, EERC, UND. Mr. Gorecki worked with the PCOR Partnership at the EERC to develop models to describe the behavior of CO_2 prior to injection into saline formations and oil fields. Mr. Gorecki led a joint venture funded by the IEA Greenhouse Gas R&D Programme and DOE to develop storage capacity/ resource coefficients to determine CO_2 storage capacity/resource estimates in saline formations. As a result of his work in developing storage capacity/resource estimates, he served on

the expert review panel on the U.S. Geological Survey's CO_2 Capacity Methodology; advised and helped to develop methodologies for the North American Energy Working Group's CO_2 storage capacity efforts between the United States, Canada, and Mexico; and advised the DOE National Energy Technology Laboratory on the third edition of the Carbon Sequestration Atlas of the United States and Canada.

Publications

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Synergistic Activities

- Served on two DOE best practice manual development committees focused on geologic storage of CO_2
- Served on the GHGT-12 and GHGT-13 Technical Review Committees
- Served on U.S. Geological Survey Storage Capacity Methodology Expert Review Panel
- Led a project focused on assessing static and dynamic CO_2 storage resource for two saline reservoirs
- Involved in the development of DOE best practice manuals for CO_2 storage

APPENDIX D

BUDGET JUSTIFICATION

EERC BUDGET JUSTIFICATION

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

BACKGROUND

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC is funded through federal and nonfederal grants, contracts, and other agreements. Although the EERC is not affiliated with any one academic department, university faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

INTELLECTUAL PROPERTY

The applicable federal intellectual property (IP) regulations will govern any resulting research agreement(s). In the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this project, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation, a separate legal entity.

BUDGET INFORMATION

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, etc.) and among funding sources of the same scope of work is for planning purposes only. The project manager may incur and allocate allowable project costs among the funding sources for this scope of work in accordance with Office of Management and Budget (OMB) Uniform Guidance 2 CFR 200.

Escalation of labor and EERC recharge center rates is incorporated into the budget when a project's duration extends beyond the university's current fiscal year (July 1 – June 30). Escalation is calculated by prorating an average annual increase over the anticipated life of the project.

The cost of this project is based on a specific start date indicated at the top of the EERC budget. Any delay in the start of this project may result in a budget increase. Budget category descriptions presented below are for informational purposes; some categories may not appear in the budget.

Salaries: Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the average rate of a personnel group with similar job descriptions. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project may be paid an amount over the normal base salary, creating an overload which is subject to limitation in accordance with university policy. As noted in the UND EERC Cost Accounting Standards Board Disclosure Statement, administrative salary and support costs which can be specifically identified to the project are direct-charged and not charged as facilities and administrative (F&A) costs. Costs for general support services such as contracts and IP, accounting, human resources, procurement, and clerical support of these functions are charged as F&A costs.

Fringe Benefits: Fringe benefits consist of two components which are budgeted as a percentage of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions.

Travel: Travel may include site visits, fieldwork, meetings, and conferences. Travel costs are estimated and paid in accordance with OMB Uniform Guidance 2 CFR 200, Section 474, and UND travel policies, which can be found at http://und.edu/finance-operations (Policies & Procedures, A–Z Policy Index, Travel). Daily meal rates are based on U.S. General Services Administration (GSA) rates unless further limited by UND travel policies; other estimates such as airfare, lodging, etc., are based on historical costs. Miscellaneous travel costs may include taxis, parking fees, Internet charges, long-distance phone, copies, faxes, shipping, and postage.

Equipment: Two pieces of equipment are needed for work on this project.

A charger rack, nodes, and a handheld terminal will be purchased to enhance an existing Seismic Data Acquisition System in operation at the EERC. This will enable the team to shoot longer 2-D seismic lines more efficiently. The total estimated cost for this enhancement is $80,542, based on a recent purchase.

The second is a computer modeling and simulation workstation for conducting modeling and simulation activities and facilitating conducting activities from partner or field site locations when necessary. The budgeted cost of $10,000 is based on a recent purchase.

Supplies: Supplies include items and materials that are necessary for the research project and can be directly identified to the project. Supply and material estimates are based on prior experience with similar projects. Examples of supply items are chemicals, gases, glassware, nuts, bolts, piping, data storage, paper, memory, software, toner cartridges, maps, sample containers, minor equipment (value less than $5000), signage, safety items, subscriptions, books, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the F&A cost.

Subcontracts:

Schlumberger Carbon Services (Schlumberger)
Schlumberger will perform services in the form of developing a drilling, logging, and coring plan for two stratigraphic test wells in the project area, as well as conducting the drilling, logging, and coring activities for each well. The estimated cost for these services is $4,406,620. This cost is based on a quote.

Prairie Public Broadcasting
Prairie Public Broadcasting will participate in the Outreach portion of the project. Activities will include collecting video footage in the feasibility study target area; conducting interviews of project participants; and producing three professional-quality, high-definition video shorts. This cost is based on a quote.

Consultants:

CETER Group
CETER Group will provide consulting services in the form of risk assessment technical support for the project. The risk assessment will be used to identify potential constraints, technical and nontechnical, that would prevent potential candidate storage reservoirs within the storage complex from serving as commercial storage sites. CETER Group is budgeted at $60,000 for this work, based on a quote of $200 per hour for 300 hours of effort.

Outreach
A consultant will be hired for work in the outreach portion of the project involving surveying and focus groups. The consultant will assist with the investigation of public perceptions of geologic carbon storage projects through the development and implementation of survey instruments and focus groups. This work includes assessment of public familiarity with geologic carbon storage, public concerns, and response to outreach materials. $30,500 is budgeted as an estimate for these services.

Communications: Telephone, cell phone, and fax line charges are included in the F&A cost; however, direct project costs may include line charges at remote locations, long-distance telephone charges, postage, and other data or document transportation costs that can be directly identified to a project. Estimated costs are based on prior experience with similar projects.

Printing and Duplicating: Page rates are established annually by the university's duplicating center. Printing and duplicating costs are allocated to the appropriate funding source. Estimated costs are based on prior experience with similar projects.

Food: Expenditures for project partner meetings where the primary purpose is dissemination of technical information may include the cost of food. The project will not be charged for any costs exceeding the applicable GSA meal rate. EERC employees in attendance will not receive per diem reimbursement for meals that are paid by project funds. The estimated cost is based on the number and location of project partner meetings.

Operating Fees: Operating fees include EERC recharge centers, outside laboratories, freight, and other fees needed to accomplish the project.

Fee – Landowner access: Fees of up to $25,000 ($5000/acre) are budgeted to be paid for landowners to permit and drill a stratigraphic test well. This estimate is based on a quote.

Fee – Seismic reprocessing: A fee is budgeted for $32,500 for an outside service to reprocess Legacy 3-D seismic data to be purchased in Task 2. This estimate is based on a vendor quote.

EERC recharge center rates are established annually. Laboratory and analytical recharge fees are charged on a per sample, hourly, or daily rate. Additionally, laboratory analyses may be performed outside the university when necessary. The estimated cost is based on the test protocol required for the scope of work.

Graphics recharge fees are based on an hourly rate for production of such items as report figures, posters, and/or images for presentations, maps, schematics, Web site design, brochures, and photographs. The estimated cost is based on prior experience with similar projects.

Shop and operations recharge fees cover specific expenses related to the pilot plant and the required expertise of individuals who perform related activities. Fees may be incurred in the pilot plant, at remote locations, or in EERC laboratories whenever these particular skills are required. The rate includes such items as specialized safety training, personal safety items, fall protection harnesses and respirators, CPR certification, annual physicals, protective clothing/eyewear, research by-product disposal, equipment repairs, equipment safety inspections, and labor to direct these activities. The estimated cost is based on the number of hours budgeted for this group of individuals.

Outside lab fees are budgeted for the creation of the thin sections and core shipping, handling and preparation for further analysis at the EERC.

Facilities and Administrative Cost: The F&A rate proposed herein is approved by the U.S. Department of Health and Human Services and is applied to modified total direct costs (MTDC). MTDC is defined as total direct costs less individual capital expenditures, such as equipment or software costing $5000 or more with a useful life of greater than 1 year, as well as subawards in excess of the first $25,000 for each award.

Cost Share: Letters of commitment are attached to the proposal for all cost-share participants.

Lignite Research Council (LRC)
LRC has committed to providing cash cost share in the amount of $1,500,000.

Computer Modelling Group, Ltd. (CMG)
CMG has committed in-kind cost share in the form of reservoir simulation software licenses, tools, and technical support. These services will be provided for a period of 24 months to support the proposed scope of work. CMG's license fee for leasing one copy each of GEM (full-field, unlimited grid cell version), BUILDER, RESULTS, WINPROP, and CMOST plus two GEM parallel tokens (allowing GEM to run in eight-way parallel mode) is $188,200 a year. The portion contributed by GMG as in-kind cost share will be US$169,380. The remaining US$18,820 in license fees will be paid by the EERC. The portion of the license to be paid through the project is listed in the detailed supply list of the budget.

Schlumberger Carbon Services
Schlumberger has committed to providing in-kind cost share valued at $2,308,096. This will be in the form of software licenses and maintenance for the duration of the project to support the geocellular modeling activities.

Prairie Public Broadcasting
Prairie Public Broadcasting will be a subcontractor on the project for the outreach task (see explanation above). Prairie Public costs are estimated at $39,000, of which Prairie Public will contribute an estimated $23,500 as in-kind cost share.

Basin Electric Power Cooperative (BEPC)
BEPC has committed to provide cost share of $500,000 in a combination of cash and in-kind. It is estimated that $300,000 will be in the form of cash and $200,000 as in-kind contributions. The in-kind contributions will consist of engineering evaluation for future implementation of CCS and transport through BEPC's existing CO_2 source via its AVS and DGC plants and an existing transport mechanism with its existing CO_2 pipeline and support infrastructure. In addition, representatives from BEPC will participate in project risk assessment evaluations, outreach team meetings, and other project stakeholder meetings to be hosted at the EERC.

ALLETE Clean Energy (ACE), BNI Energy, Minnkota Power Cooperative (Minnkota)
ACE, BNI Energy, and Minnkota have committed to provide cost share of $300,000 in a combination of cash and in-kind. It is estimated that $200,000 will be in the form of cash and $100,000 as in-kind contributions. In-kind contributions will include 1) working with the EERC to establish viable business scenarios for an integrated carbon capture and storage project at the Milton R. Young Station; 2) waiving fees for land access as well as assisting with site preparation and reclamation to drill a stratigraphic test well; and 3) participation in project risk assessment evaluations, outreach team meetings, and other project stakeholder meetings to be hosted at the EERC.

North American Coal
North American Coal has committed in-kind cost share totaling $100,000 by providing expertise and insight into the regulatory aspects of the lignite industry and the implications of CCS implementation to the lignite industry. North American Coal also has agreed to provide assistance with wellsite preparation and reclamation to drill a stratigraphic test well. North American Coal will participate in project risk assessment evaluations, outreach team meetings, and other project stakeholder meetings to be hosted at the EERC.

APPENDIX E

REFERENCES

REFERENCES

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Glazewski, K.A., Grove, M.M., Peck, W.D., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2015, Characterization of the PCOR Partnership region: Plains CO_2 Reduction (PCOR) Partnership Value-Added Report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-02-14, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

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