PLAINS CO_2 REDUCTION PARTNERSHIP

EERC Proposal No. 2004-0048

Submitted to:

Ms. Karlene Fine

Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue
State Capitol, 10th Floor
Bismarck, ND 58505-0310

Amount of Request: $240,000

Submitted by:

Thomas A. Erickson
John A. Harju
Daniel J. Daly
James A. Sorensen
Edward N. Steadman

Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202-9018

_____
Thomas A. Erickson, Project Manager

_____
Dr. William D. Gosnold Jr., Interim Director
Office of Research and Program Development

September 2003

TABLE OF CONTENTS

LIST OF FIGURES ii

LIST OF TABLES ii

ABSTRACT iii

PROJECT SUMMARY 1

PROJECT DESCRIPTION 2
- PCORP Program 2
- PCORP Team 4
- PCORP Facilities and Capabilities 5
- Economic and Technical Impacts 5

STANDARDS OF SUCCESS 6

BACKGROUND 6
- Introduction 6
- PCORP Region Definition and Attributes 7
- Sources 7
  - Geologic Sinks 8
  - Terrestrial Sinks 9
  - Anthropogenic CO_2–EOR Projects 9

QUALIFICATIONS 10

VALUE TO NORTH DAKOTA 11

MANAGEMENT 14

TIMETABLE 16
- Task 1 – Management, Reporting and Technical Outreach 16
- Task 2 – Technology Deployment Issues. 18
- Task 3 – Public Perception and Outreach 18
- Task 4 – Regional Characterization 19
- Task 5 – Technology Selection and Action Plans 20
- NDIC Reporting 21

BUDGET AND MATCHING FUNDS 21

TAX LIABILITY 21

continued...

TABLE OF CONTENTS (continued)

CONFIDENTIAL INFORMATION 21

REFERENCES 22

TECHNICAL SECTION OF PCORP PROPOSAL AWARDED TO THE EERC BY THE DOE ..... Appendix A

LETTERS OF COMMITMENT AND SUPPORT ..... Appendix B

RESUMES OF KEY PERSONNEL ..... Appendix C

DETAILED BUDGET AND BUDGET NOTES ..... Appendix D

LIST OF FIGURES

1 PCORP region 3

2 PCORP project in the context of DOE's three-phase RCSP program 3

3 PCORP management diagram 15

4 Milestones and deliverables for tasks and subtasks 17

LIST OF TABLES

1 PCORP Team 5

2 Summary of 1999 CO_2 Emissions in the U.S. Portion of the PCORP Region 7

3 Estimated CO_2 Emissions from Coal-Fired Power Plants in and Around the PCORP Region 8

4 Summary of the Qualifications and Responsibilities for Key PCORP Organizations 12

5 Summary of Expertise of Key PCORP Personnel 13

PLAINS CO_2 REDUCTION PARTNERSHIP

ABSTRACT

The EERC was recently awarded a DOE contract to develop the "Plains CO_2 Reduction Partnership" (PCORP), a collaborative regional framework to support the testing and demonstration of CO_2 sequestration technologies in the northern Great Plains of North America. The PCORP region includes five states (ND, SD, MN, MT, and WY) and two Canadian provinces (SK and MB). The diverse PCORP team, led by the EERC and further profiled below, has the expertise, experience, facilities, and capabilities to fulfill DOE's project goals.

Industry Sponsors	Research Partners	Collaborators
Basin Electric Power Cooperative	EERC	Western Governors' Association
Dakota Gasification Company	Dakota Gasification Company	Amerada Hess Corporation
Montana-Dakota Utilities Co.	Nexant-Bechtel	Environment Canada
Otter Tail Power Company	North Dakota State University	Interstate Oil and Gas Compact Commission
Great River Energy	Prairie Public Television	Petroleum Technology Transfer Council
U.S. Department of Energy	Fisher Oil and Gas	NDIC Oil and Gas Division
North Dakota Industrial Commission		North Dakota Geological Survey
		Minnesota Pollution Control Agency
		North Dakota Department of Health
		Montana Department of Environmental Quality

The overall goals of PCORP are to develop and implement a partnership framework in the northern Great Plains region as a basis for identifying cost-effective CO_2 sequestration systems that meet the needs of the region, and then, in Phase II, to accelerate, facilitate, and manage the testing of these technologies. These systems will be used as a basis for subsequent large-scale demonstration and deployment of sequestration technologies. PCORP's Phase I objectives include the evaluation of options and potential opportunities for regional CO_2 sequestration and the development of action plans for the implementation of small-scale validation testing of the most promising technologies. PCORP activities will also promote the implementation of technology for the capture, transport, and storage of anthropogenic fossil fuel CO_2 emissions across the United States.

The PCORP project will last 2 years (October 2003 – September 2005). The total cost of the project is $2,748,139, which includes $1,586,614 from DOE, $30,000 each from four regional utilities, and this request of $240,000 from NDIC. The remainder of $801,525 is in-kind contributions from the various team members of which the largest contributor is Dakota Gasification Company ~$700,000).

PLAINS CO_2 REDUCTION PARTNERSHIP

PROJECT SUMMARY

The Plains CO_2 Reduction Partnership (PCORP) at the Energy & Environmental Research Center (EERC) has been established as a Phase I Regional Carbon Sequestration Partnership (RCSP) project for the northern Great Plains, an area that covers five states and two Canadian provinces.

The overall goals of PCORP are to develop and implement a partnership framework in the northern Great Plains region as a basis for identifying cost-effective CO_2 sequestration systems that meet the needs of the region and then to accelerate, facilitate, and manage the testing of these technologies. These systems will be used as a basis for subsequent large-scale demonstration and deployment of sequestration technologies in accordance with the President's goal of reducing CO_2 by at least 18% by the year 2012 while simultaneously enhancing the economy. PCORP's Phase I objectives include the evaluation of options and potential opportunities for regional CO_2 sequestration and the development of action plans for the implementation of small-scale validation testing of the most promising technologies. PCORP activities will also promote the implementation of technology for the capture, transport, and storage of anthropogenic fossil fuel CO_2 emissions across the United States.

PCORP will accomplish the project objectives by:

1. Characterizing the region with respect to CO_2 sources, sinks, and storage options and matching sources and sinks.
2. Identifying and addressing issues for technology deployment.
3. Developing public involvement and education mechanisms.
4. Identifying the most promising capture, sequestration, and transport options.

5. Preparing action plans for implementation and technology validation activities.

6. Providing efficient and effective management and reporting.

PROJECT DESCRIPTION (additional detail can be found in the attached proposal, Appendix A, Sections 2–5)

PCORP Program

In response to U.S. Department of Energy (DOE) Program Solicitation DE-PS26-03NT41713, "Regional Carbon Sequestration Partnerships (RCSP) – Phase I," the EERC will develop and coordinate PCORP, an international stakeholder-based framework and accompanying methodology designed to identify the major CO_2 sequestration opportunities in the northern Great Plains region, as shown in Figure 1, and develop action plans to facilitate small-scale demonstrations of CO_2 sequestration technologies. This region, including North Dakota, South Dakota, Minnesota, Montana, and Wyoming as well as a portion of Canada, was chosen based on a synergy between low-rank (lignite and subbituminous) coal users, geologic sinks, current CO_2 activities, terrestrial sinks, and existing industry collaborations. PCORP will work in concert with DOE RCSP program managers, as well as other RCSP-funded centers and related programs, to fully realize the vision of reducing carbon intensity, increased efficiency, and carbon sequestration expressed in the "Carbon Sequestration Technology Roadmap and Program Plan" (1). PCORP will work to strengthen and expand its membership and technical base over the course of the program, and all activities will be conducted in consideration of affordably meeting U.S. energy demand and environmental concerns.

As shown in Figure 2, the goals of this program will be implemented through a management task and four performance tasks using a three-step approach. The PCORP proposal features a management task (Task 1) and four technical tasks (Tasks 2, 3, 4, and 5) in a three-

Figure 1. PCORP region.

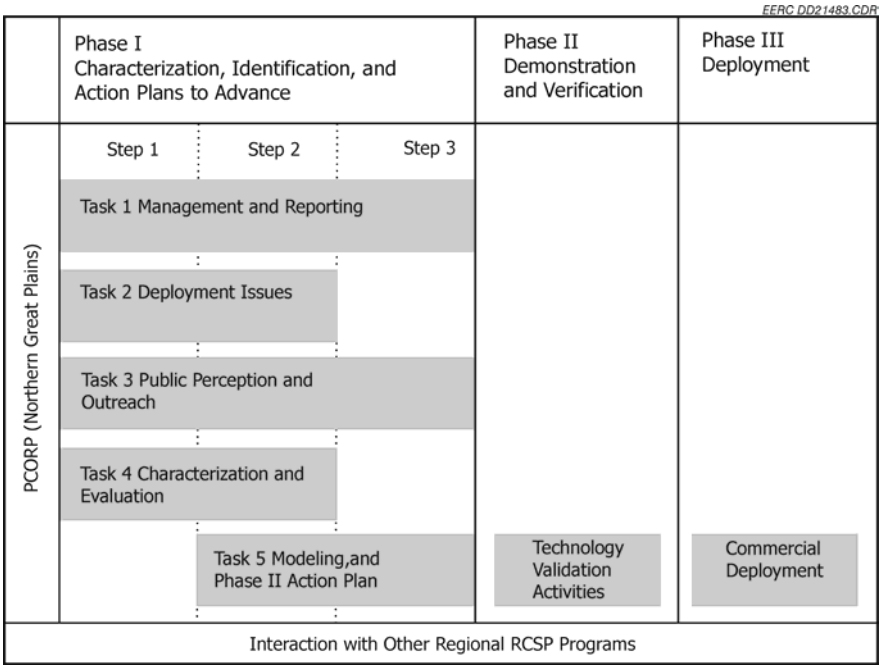

Figure 2. PCORP project in the context of DOE's three-phase RCSP program.

step approach. Step 1 characterizes technical issues and the public's understanding and attitudes concerning CO_2 sequestration, including development of a database on sources, sinks, separation and transportation options, regulatory permitting requirements, and environmental benefits and risks. Step 2 identifies regional opportunities for sequestration and informs the public about options and risk. Step 3 develops a detailed action plan for implementing demonstration projects in the PCORP region. The PCORP partners will contribute over the life of the project through working groups that are designated to focus on key topical areas. The EERC will manage and coordinate all project activities to ensure effective and timely reporting to DOE, collaboration with other RSCP programs, and outreach to the public and the technical community. Additional detailed information on the technical approach can be found in the attached DOE proposal in Appendix A.

PCORP Team

As shown in Table 1, PCORP features a diverse, multipartner team under EERC leadership that brings together the key government, private sector, technical, and outreach groups needed to undertake the activities in the four performance tasks. The PCORP team is well suited to assess the regional baseline and infrastructure and to involve stakeholders in developing action plans for Phase II. The PCORP team includes 1) industry sponsors that provide cost share and serve as advisors; 2) research partners that are funded under the PCORP venture; and 3) collaborators that, in most cases, provide in-kind support. The industry sponsors have significant and active operations in all five states of the region. The knowledge base, expertise, and hands-on experience of the PCORP research team encompass the entire region.

Table 1. PCORP Team

Industry Sponsors	Research Partners	Collaborators
Basin Electric Power Cooperative	EERC	Western Governors' Association
Dakota Gasification Company	Dakota Gasification Company	Amerada Hess Corporation
Montana-Dakota Utilities Co.	Nexant-Bechtel	Environment Canada
Otter Tail Power Company	North Dakota State University	Interstate Oil and Gas Compact Commission
Great River Energy	Prairie Public Television	Petroleum Technology Transfer Council
U.S. Department of Energy	Fisher Oil and Gas	NDIC Oil and Gas Division
North Dakota Industrial Commission		North Dakota Geological Survey
		Minnesota Pollution Control Agency
		North Dakota Department of Health
		Montana Department of Environmental Quality

PCORP Facilities and Capabilities

The EERC and its PCORP partners bring a unique combination of capabilities and facilities to the PCORP project. The EERC's 210,000 square feet of laboratory, technology demonstration, and office space, located on the southeast corner of the University of North Dakota (UND) campus, house state-of-the-art facilities for analysis, fabrication, and laboratory- to pilot-scale testing and verification. All facilities are available for PCORP and RCSP Phase II activities. In addition, the EERC has the facilities, equipment, and experienced personnel to undertake 1) relational database design, 2) geographic information system (GIS) programming, 3) database applications and decision support tools, and 4) predictive modeling. PCORP's industrial sponsors and collaborative partners have sites and facilities that could be used for the demonstration of CO_2 separation, transportation and capture technologies, and indirect and direct (disposal and value-added) sequestration during RCSP Phase II activities.

Economic and Technical Impacts

The activities within this project will support existing and future opportunities to gain value from existing CO_2 emissions. Currently, there are two entities within the state of North Dakota who are currently conducting preliminary evaluations on the use of CO_2 for enhanced oil recovery. The PCORP program will be available to help those entities with their planning and

feasibility studies. The overall focus of this project is on CO_2 sequestration options that are technically and economically feasible for the future. The final product of this activity will be a series of action plans for DOE to consider for future implementation in the region to demonstrate concepts.

STANDARDS OF SUCCESS

The overall success of this project will be determined through the successful implementation of a Phase II demonstration project and subsequent commercial application within the PCORP region. This overall success is based on identifying candidate opportunities and addressing and solving the economic, technical, environmental, and regulatory concerns facing those opportunities. Communication with a broad spectrum of stakeholders in this program will also be essential for the long-term success and will be monitored throughout the project.

BACKGROUND

Introduction

Successful CO_2 sequestration projects, including value-added projects, require appropriate combinations of sources, separation technologies, sinks, and transportation infrastructure to move the CO_2 from source to sink. This section describes the PCORP region and its attributes; the approach that will be taken to characterize the PCORP region's sources, sinks, and infrastructure; and an approach for data management (Task 4). This section also describes the approach for developing modeling criteria needed to determine major opportunities for sequestration in the region and the approach for action plan development (Task 5).

PCORP Region Definition and Attributes

As shown in Figure 1, the PCORP region includes North Dakota, South Dakota, Minnesota, and portions of Montana and Wyoming in the United States, as well as portions of the Canadian provinces of Saskatchewan and Manitoba. The PCORP region was defined on the basis of similarities in large stationary CO_2 sources, similarities in geologic and terrestrial CO_2 sinks, transport considerations for direct CO_2 sequestration, and the presence of two major value-added, anthropogenic CO_2–EOR sequestration projects. This combination of regional attributes, detailed below, makes the PCORP region well suited to meet DOE's criteria for the RCSP – Phase I program.

Sources

As shown in Table 2, the U.S. portion of the PCORP region produced 67.63 MMTCE (million metric tons carbon equivalent) of anthropogenic CO_2 in 1999, about 4.6% of the U.S. total. Major stationary sources (utility and industrial) contributed 44.86 MMTCE, or two-thirds, of the 67.63-MMTCE total for the region. The utility sector, including the 34 sources of greater than 100-MW capacities, contributes 33.24 MMTCE, representing half of the CO_2 emissions for the region. The industrial sector, including 27 ethanol facilities (2), accounted for an additional 11.62 MMTCE. To meet the President's Global Climate Change Initiative (GCCI) goal, CO_2 emissions in the region would need to be reduced 18% (12.17 MMTCE) by 2012 (see Table 3).

Table 2. Summary of 1999 CO_2 Emissions in the U.S. Portion of the PCORP Region (3)

State	Utility	Industrial	Other Stationary	Transportation	State Total
MN	8.00	3.72	3.75	9.56	25.02
MT	4.36	1.43	0.54	2.04	8.37
ND	8.53	3.19	0.55	1.55	13.82
SD	0.98	0.58	0.47	1.60	3.63
WY	11.37	2.70	0.45	2.26	16.79
PCORP Total	33.24	11.62	5.76	22.77	67.63
U.S. Total					1477.32

Table 3. Estimated CO_2 Emissions from Coal-Fired Power Plants in and Around the PCORP Region

Coal-Fired Power Plants	Plant State	Fuel	Geologic Province	Annual Utility Emissions By State, MMTCE
Fox Lake	MN	NG	SA	8.0
Clay Boswell	MN	S	SA	
M.L. Hubbard	MN	O	SA	
Black Dog	MN	S	SA	
Blue Lake	MN	S	SA	
High Bridge	MN	S	SA	
Inver Hills	MN	O	SA	
King	MN	S	SA	
Riverside	MN	S	SA	
Sherburne	MN	S	SA	
Colstrip	MT	S	PRB	4.36
JE Corette	MT	S	PRB	
Lewis & Clark	MT	L	WB	
Antelope Valley	ND	L	WB	8.53
Coal Creek	ND	L	WB	
Coyote	ND	L	WB	
Heskett	ND	L	WB	
Leland Olds	ND	L	WB	
Stanton	ND	L	WB	
Young	ND	L	WB	
Ben French	SD	S	WB	0.98
Big Stone	SD	S	WB	
Argo Anson	SD	NG	SA	
Dave Johnson	WY	S	PRB	11.37 (7.2)
Laramie River	WY	S	PRB	
Neil Simpson 1	WY	S	PRB	
Neil Simpson 2	WY	S	PRB	
Osage	WY	S	PRB	
Wyodak	WY	S	PRB	

NG = natural gas; SA = Sioux Arch; S = subbituminous coal; O = oil; PRB = Powder River Basin; L = lignite coal; WB = Williston Basin

Geologic Sinks

The PCORP region includes the Williston Basin and the Powder River Basin. Both of these are significant hydrocarbon-producing basins that include significant production from carbonates. These basins have active or planned sequestration projects related to value-added conventional oil or coalbed methane (CBM) production, as well as recognized potential for sequestration in deep aquifers, exhausted hydrocarbon production units, and unminable coal seams. For example, the Williston Basin is one of five U.S. basins that has an active CO_2–EOR project (i.e., DGC–EnCana Weyburn project [4, 5]), a successful demonstration in other

conventional oil fields (i.e., the Little Knife Field test by Gulf Oil Exploration and Production [6]), and has more than a dozen candidates evaluated for CO_2–EOR projects (7).

Terrestrial Sinks

The semiarid, rolling grasslands of the plains dominate the western portion of the region and are currently used for grazing and growing small grains, and the forested landscape of the northeast and north offer opportunities for testing and verification of soil and vegetative technologies. Agricultural soils in the PCORP region have the potential to take up 0.2 to 0.45 tons of carbon per hectare (e.g., 1.6 MMTCE per year for the 16.2 million ha of arable land in North Dakota) (8). Studies in Canada suggest that the 15 million acres of Minnesota forest area (6.1 million ha) has the capacity to take up about 0.27 MMTCE per year in timber through 2050 (8).

Anthropogenic CO_2–EOR Projects

The PCORP region contains projects involving two of the four U.S. industrial sources of CO_2 and five of the 74 CO_2–EOR projects in the United States and accounts for a significant portion of the 7 MMTY of anthropogenic CO_2 currently used for EOR (6). The Weyburn CO_2–EOR project on the northwest flank of the Williston Basin involves EnCana and DGC. The US$750 million Weyburn project moves 5000 tons of CO_2 per day by dedicated pipeline from the DGC facility in west-central North Dakota to the Weyburn oil field in southeastern Saskatchewan, Canada. Weyburn is the only CO_2–EOR project utilizing CO_2 from a coal conversion unit and is projected, over its 20-year life, to result in the production of an additional 120 million barrels of oil and the sequestration of 19 million (net) metric tons of CO_2 (5, 9). The LaBarge gas plant, proximal to the PCORP region, would be a candidate for supplying CO_2 for EOR in the Salt Creek field in the Powder River Basin (4).

QUALIFICATIONS

The EERC has the proven ability to develop and lead multiyear, multidisciplinary, multiclient programs, including many public–private and stakeholder-based partnerships like PCORP. The EERC was established in 1949 as a federal research facility under the U.S. Bureau of Mines and later became the lead laboratory for low-rank coals under DOE. The center was defederalized in 1983 and became a business unit of UND. The EERC currently has an annual budget of $20 million, covering 241 contracts, three quarters of which are private sector clients. In the last 15 years, the EERC has worked with over 720 clients in all 50 states and in 47 countries. The EERC's multidisciplinary staff of more than 260 has maintained its leading role in coal research and has expanded its expertise and partnerships in a broad spectrum of energy and environmental programs. The EERC has successfully completed projects involving geological characterization of subsurface resources, experimental design, analytical methods development, groundwater quality, biomass-based energy, advanced power systems, atmospheric emission controls, reclamation of disturbed lands, disposal and value-added waste management, disposal site characterization, site remediation for oil and gas, cleanup of the federal weapons complex and industry sites, and training activities from local to international scope.

The EERC's success in effectively serving a broad client base has been supported by its long-standing partnership with DOE through the National Energy Technology Laboratory (NETL). Examples of the successful partnership include the Fossil Energy Cooperative Agreement (1983 to present), the Environmental Management Cooperative Agreement (1985 to present), the Biomass Cooperative Agreement (2000 to present), and projects involving industry–government partnerships under the Jointly Sponsored Research Program (1983 to present), which has attracted more than $30 million of industrial cash support. The EERC has

projects and strong working relationships with a number of other state and federal agencies including the U.S. Department of Defense, U.S. Department of the Interior, U.S. Environmental Protection Agency (EPA), U.S. Department of Agriculture, U.S. Geological Survey, and Agency for International Development.

Key personnel for PCORP include select administrative and technical staff from all of the research partners, representing a broad range of scientific and engineering disciplines and real-world experience. Relevant EERC expertise includes project management; design, procurement, fabrication, installation, and testing of conventional and advanced systems for energy conversion and emissions sampling and control; data management and GIS; geological characterization and assessment; systems engineering; and public outreach. The PCORP partners bring technical expertise in sources, systems, permitting and regulations, transportation, CO_2 sequestration (including value-added applications), and outreach. Table 4 profiles the expertise and project roles for partners and collaborators on the PCORP team. Table 5 profiles key personnel in terms of the expertise needed to fulfill DOE's project criteria and gives the percentage of time for each person.

VALUE TO NORTH DAKOTA

The continued operation of existing coal-fired utilities as well as future systems in North Dakota is highly dependent on being able to meet the environmental regulations associated with coal combustion. Though currently not regulated, carbon emissions will likely be a significant driver for the future of electricity production. The Chicago Climate Exchange will begin trading greenhouse gas credits on October 1 2003, on a national scale.

Table 4. Summary of the Qualifications and Responsibilities for Key PCORP Organizations

			Task 1	Task 4			Task 2	Task 3	Task 5	
Role	**Organization**	**Expertise/Capability**	**Mgt., Reporting**	**Source**	**Sink**	**CO_2 Separation and Transport**	**Regulatory Issues**	**Public Outreach**	**Technology Assessment**	**Action Plans**
Project Management	EERC	Management of multipartner, multidisciplinary research, development, and commercialization projects; stakeholder-based consortia. Multidisciplinary staff of over 250 with expertise in coal-fired energy systems, energy environmental issues, technology development, verification and deployment, data management, GIS, and public outreach and education Experienced staff and capabilities for contract management, accounting, report preparation, public relations and outreach, workshops and meetings, award-winning Web site, and graphics department	P	P	P	P	P	P	P	P
Research Partners	DGC	CO_2 separation from coal gasification process; CO_2 transportation; CO_2 sequestration project development and implementation; candidate sites for technology testing and verification (one of four sources of anthropogenic CO_2 with CO_2 stream currently used in a CO_2–EOR sequestration project in the United States [Weyburn project])		S	S	P	S		S	S
	Fisher Oil and Gas	Regional geology, enhanced oil and gas recovery, injection issues, risk assessment			P		S		S	S
	Nexant-Bechtel	Technical expertise in CO_2 separation and sequestration and technical and efficiency issues.				P	S		P	S
	North Dakota State University	Technical expertise agricultural practices, issues, policy, and terrestrial CO_2 sequestration strategies			P		S		S	S
	Prairie Public Television	Television coverage for entire PCORP region, key audience share, video production and distribution, gateway to other media sectors						P		
Industrial Sponsors	Basin Electric Power Cooperative, DGC, Montana-Dakota Utilities, Otter Tail Power, NDIC, Great River Energy	Candidate sites for technology testing and verification activities, facilitated technology transfer, input from key stakeholders on project direction and implementation		S			S	S	S	S
Collab-orating Partners	State, provincial, and federal regulatory agencies; Western Governors' Association; Petroleum Technology Transfer Council; Amerada Hess, Environment Canada	Permitting and regulatory issues at the state, provincial and federal level, environmental risk assessment			S		P	S	S	S

P=primary role; S=secondary role

Table 5. Summary of Expertise of Key PCORP Personnel

Name	Organization	Management of Large Multidisciplinary Programs	Environmental Policy, Permitting, and Regulations	CO_2 Chemistry and Science	Geological Sequestration	Terrestrial Sequestration	Power Systems/Power Industry	Oil and Gas Industry	GIS/Data Management	Education and Outreach	Emissions Control Technologies	Site Characterization/Site Assessment	**Percentage of Time on Project**
Daly, D.	EERC								X	X			21
Erickson, T.	EERC	X					X			X	X		36
Evans, J.	EERC	X	X					X	X			X	5
Fisher, D.	Fisher Oil and Gas				X			X				X	20
Faller, T.	North Dakota State University (NDSU)			X		X							8
Harju, J.	EERC	X	X		X			X				X	12
Hawthorne, S.	EERC			X				X				X	3
Laudal, D.	EERC						X				X		17
Leistritz, L.	NDSU		X			X							9
Lukes, A.	DGC				X			X					2
Musich, M.	EERC						X				X		29
Nelson, C.	EERC				X			X				X	4
O'Leary, E.	EERC								X				13
Peck, W.	EERC								X				15
Ruby, J.	Nexant-Bechtel	X					X				X		10
Sondreal, E.	EERC						X				X		8
Sorensen, J.	EERC	X	X		X			X				X	30
Steadman, E.	EERC	X								X			34
Weber, G.	EERC	X					X				X		13

The lignite industry will be heavily affected if carbon limits are established, and potential sequestration and offset options must be determined. In addition to having a lower, overall system efficiency, the amount of moisture and contaminants in the flue gas will require more extensive cleaning and separation than most other coal types. The overall goal of this activity is to identify the best candidate opportunities for carbon sequestration in this region that will be both technologically and economically feasible within the framework of the region.

Successful conduct of this program and its subsequent phases can provide tremendous economic benefit to the state of North Dakota. To date, cumulative oil production from unitized pools active today in North Dakota totals approximately 775 million barrels. Projections made by the North Dakota Industrial Commission's (NDIC) Oil & Gas Division (OGD) suggest that the estimated ultimate recovery of oil, including that recovered via waterflood, from those unitized pools will be 955 million barrels of oil (only 180 million barrels left). NDIC OGD projects that an additional 280 million barrels of oil could be recovered through the use of CO_2 EOR. Using the Weyburn field in Saskatchewan as an analog, where incremental production of 1 barrel of oil has utilized approximately 4000 scf of CO_2, a gross market projection of 1.12 TCF of CO_2 in North Dakota alone could be realized by North Dakota's coal-fired utilities, should they be the ultimate suppliers of that CO_2 (Lynn D. Helms, director, NDIC OGD personal communication).

MANAGEMENT

PCORP is structured to ensure optimal input by diverse stakeholders, to function in a practical and cost-effective manner, and to deliver credible, timely results. As shown in Figure 3, the PCORP organization is built around four technical tasks (Tasks 2–5). Each task has an EERC lead and is supported by one or more working groups made up of partners and other stakeholders and focused on key topics or subtasks. Leads for the working groups are either EERC personnel

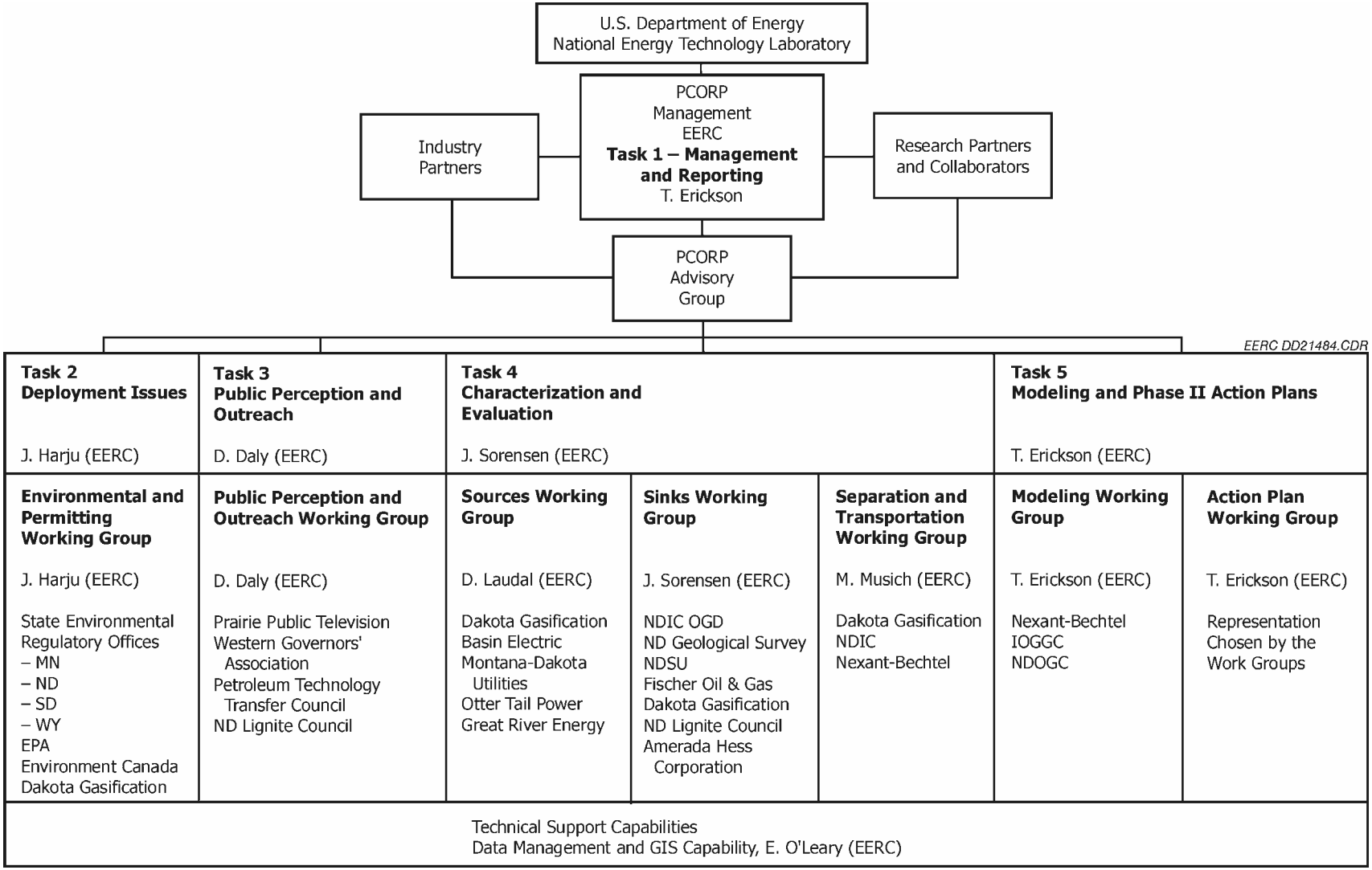

Figure 3. PCORP management diagram.

or funded PCORP partners. Mr. Thomas Erickson, EERC Associate Director for Research, will serve as Project Manager for PCORP, with input on program direction through the PCORP Advisory Group, and will also serve as the principal point of contact between PCORP and the NETL Program Managers. He will have overall responsibility for the EERC PCORP contract and will interface regularly with task leaders and EERC senior management. He will be responsible for regular reporting to NETL program management, timely dissemination of information to the CO_2 sequestration community, and coordination with other partnerships developed under DOE's RCSP program. Leads for the four performance tasks will ensure the progress of the working groups and timely completion of milestones, including program deliverables. Resumes for all key personnel are shown in Appendix C.

TIMETABLE

The detailed tasks and the associated timetable (Figure 4) are discussed below.

Task 1 – Management, Reporting, and Technical Outreach

Task 1, composed of three subtasks, will continue for the duration of the project and will consist of initial organization and formalization of the PCORP structure, PCORP coordination, project management and contractual reporting, and outreach to the CO_2 sequestration technical community. Subtask 1.1 – Organization and Coordination – will ensure that PCORP is appropriately organized, activities are coordinated, the program draws fully on the diverse assets represented by the PCORP partnership, and regular and effective communication between DOE RCSP program management the PCORP Advisory Group, task managers, and working group leads. Subtask 1.2 – Management and Reporting – will ensure timely completion of milestones, the quality of deliverables, the appropriate allocation of resources and personnel, and accurate and timely project reports. This task also includes meetings (semiannual or as otherwise directed)

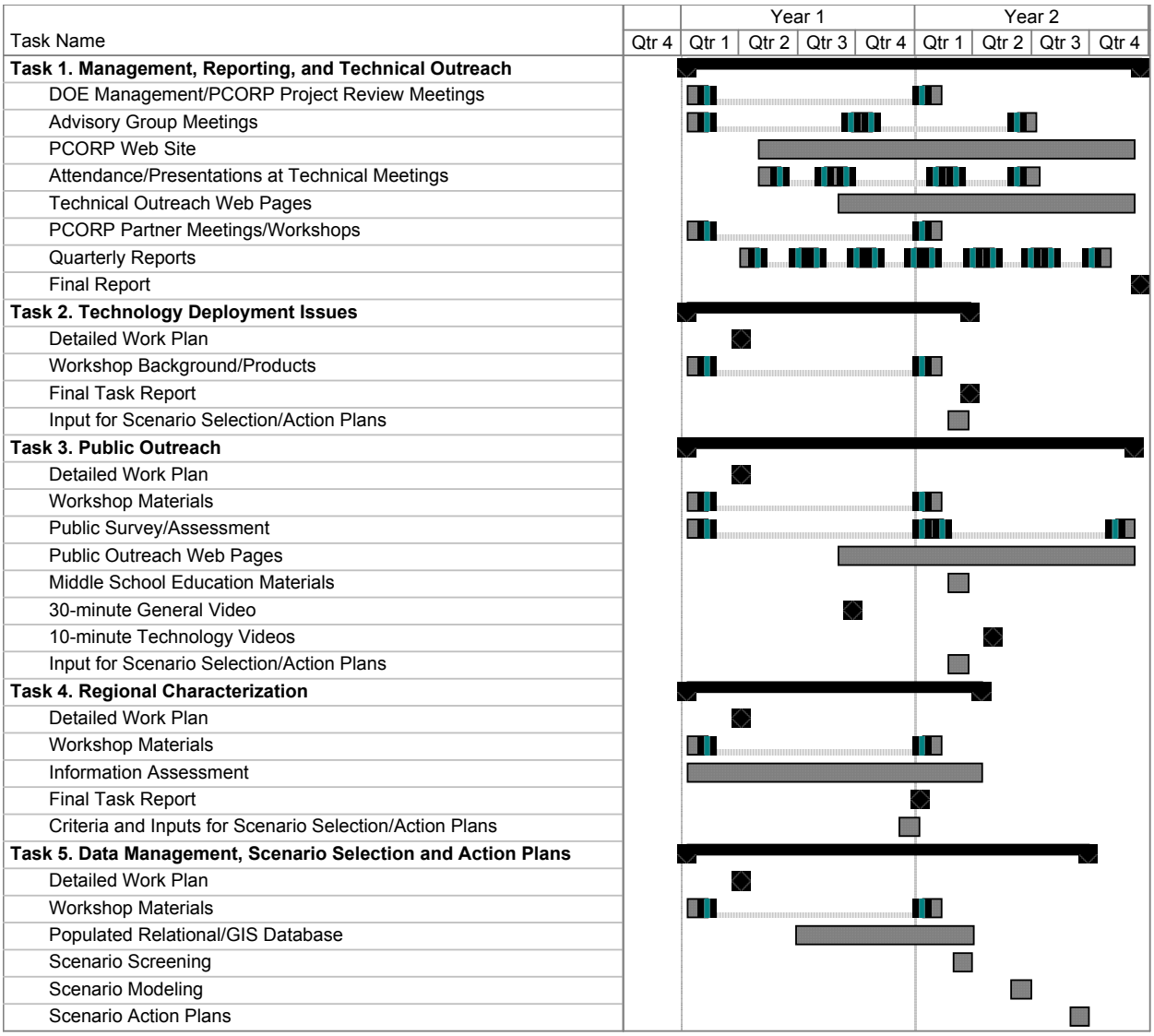

Figure 4. Milestones and deliverables for tasks and subtasks.

between representatives of the PCORP Advisory Group, the PCORP management team, and DOE Project Managers. Subtask 1.3 – Technical Outreach will provide PCORP visibility in the CO_2 sequestration community and timely dissemination of PCORP's technical results through attendance and presentations at two technical meetings per year, distribution of technical support materials, posting of technical materials on the Web, and regular communication with other RCSP groups and related programs.

Task 2 – Technology Deployment Issues

Task 2, containing five subtasks undertaken through the environmental efficacy and permitting working groups, will identify and evaluate technology deployment issues for the PCORP region. Subtask 2.1 – Task Management and Support provides for the development of a detailed task work plan, coordination of working group activities, development of materials for annual workshops, reporting to the PCORP manager and the PCORP Advisory Group, and preparation of contractual documents. Subtask 2.2 – Safety, Regulatory, and Permitting will focus on the identification and resolution of safety, regulatory and permitting issues. Subtask 2.3 – Ecosystem Considerations will evaluate the environmental effects of sequestration options and will develop an environmental baseline and assessments for specific sequestration options. Subtask 2.4 – PCORP Project Monitoring and Verification Plan will assess monitoring and verification strategies for use with sequestration scenarios in the region. Subtask 2.5 – Inputs for Modeling and Action Plans will formalize inputs for the database management systems (DBMS) criteria for screening and modeling and information for the action plans for Phase II.

Task 3 – Public Perception and Outreach

Task 3, containing seven subtasks undertaken through the public perception and outreach working group, is designed to gauge public understanding of climate change issues and CO_2 sequestration as a basis for developing and implementing a public outreach program featuring educational materials and video productions. Subtask 3.1 – Management and Support will coordinate working group activities, develop materials for annual workshops, prepare reports for PCORP management, and prepare contractual documents. Subtask 3.2 – Public Perception Assessments will gauge public perception and understanding of key issues at three points during the PCORP project to aid in outreach program development. Subtask 3.3 – Fact Sheets will

develop fact sheets that will serve as the basis for other outreach materials and ensure a consistent outreach message. Subtask 3.4 – Fact Sheets will provide consistent, factual reporting on sequestration policies. Subtask 3.5 – PCORP Web Pages will develop Web pages for posting on the EERC's Web site and will provide for links with other pertinent sites. Subtask 3.6 – PCORP Education Materials will develop and disseminate curricula materials through established regional programs. Under Subtask 3.7 – Video Development, Prairie Public Television will develop a 30-minute informational video and three 10-minute videos focused on Phase II projects that will be aired on television and used in other outreach venues. Subtask 3.8 – Input for Technology Selection and Action Plans will formalize criteria for screening and modeling and provide input for the action plans for Phase II activities.

Task 4 – Regional Characterization

Task 4 will be accomplished through three working groups (sources, sinks, and separation and transportation) that will assess sources, sinks, options for CO_2 separation, and CO_2 transportation options and will develop inputs for scenario modeling and action plan development for Phase II activities. Subtask 4.1 – Task Management and Support provides for the coordination of working group activities, development of materials for annual workshops, reporting to the PCORP management, and preparation of contractual documents. Subtask 4.2 – Characterization of PCORP Regional CO_2 Sources will characterize significant sources of CO_2 emissions including the 29 coal-fired power plants in the region (greater than 100 MW), the DGC facility, and other major industrial sources such as the 27 ethanol production and gas-processing facilities. Subtask 4.3 – Characterization of PCORP Regional CO_2 Sinks, involving the sink working group, will characterize regional geologic and terrestrial sinks and assess their characteristics with respect to potential CO_2 sequestration options, including value-added options

such as enhanced production of oil and gas resources. Subtask 4.4 – Characterization of PCORP Infrastructure, involving the separation and transportation working group, will characterize the existing infrastructure and quantify the needs for additional infrastructure to support deployment of CO_2 sequestration. Subtask 4.5 – Input for Task 5 involves representatives of several working groups collaborating to formalize criteria for screening and modeling and to provide input for the Action Plans in support of Phase II activities.

Task 5 – Technology Selection and Action Plans

Task 5, undertaken by the modeling and action plan working groups, will identify promising capture, transport, and sequestration options through a screening and modeling activity followed by the development of action plans for the projects to be undertaken under RCSP Phase II. In addition, Task 5 includes the development of a DBMS to house data for use in assessment and modeling activities. Subtask 5.1 – Task Management and Support provides for the development of a detailed task work plan, coordination of working group activities, development of materials for annual workshops, reporting to the PCORP management, and the preparation of contractual documents. Subtask 5.2 – Development of Data Management System will develop a DBMS that integrates new and existing regional databases, GIS, and Web programming to query, analyze, and map data with respect to the character and economics of sources, sinks, and infrastructure issues (all in Task 4); environmental and permitting information (Task 2); and information important to assessing public perception and providing effective public outreach (Task 3). Subtask 5.3 – Scenario Screening will develop and implement a screening matrix to ensure realistic alternatives and set practical limits on the number and types of project scenarios for RCSP Phase II as well as later R&D applications. Subtask 5.4 – Scenario Modeling will develop and utilize a computer-based methodology, using commercial spreadsheet

software, to assess and rank scenarios for Phase II RCSP projects as well as long-term R&D applications. Subtask 5. 5 – Action Plan Development will prepare detailed action plans for sequestration implementation and technology validation activities to be performed in Phase II to include plans for public involvement, regulatory and permitting requirements, and performance matrices and cost accounting.

NDIC Reporting

NDIC will be provided with all quarterly and interim reports that are provided to DOE as well as a final report at the conclusion of the project (September 2005).

BUDGET AND MATCHING FUNDS

The detailed budget for this project is in Appendix D. The total cost of the project is $2,748,139, which includes $1,586,614 from DOE, $30,000 each from four regional utilities (Great River Energy, Basin Electric, Montana-Dakota Utilities, and Otter Tail Power), and this request of $240,000 from the North Dakota Industrial Commission. The remainder of $801,525 is in-kind contributions from the various team members, of which the largest contributor is Dakota Gasification (~$700,000). Letters of commitment and support from each of the partners are in Appendix B.

TAX LIABILITY

The EERC—a research organization within the University of North Dakota, which is an institution of higher education within the state of North Dakota—is not a taxable entity.

CONFIDENTIAL INFORMATION

None

REFERENCES

1. National Energy Technology Laboratory. Carbon Sequestration Technology Roadmap and Program Plan. http://netl.doe.gov/coalpower/sequestration (accessed March 12, 2003).
2. Renewable Fuels Association. U.S. Fuel Ethanol Production Capacity. http://ethanolrfa.org/eth_prod_fac.html.
3. U.S. Environmental Protection Agency. State Energy CO_2 Inventories. http://yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsIndividual.html.
4. Thomas, D. (Advanced Resources International). Climate Change: A Challenging Opportunity for Industry and Government: Presentation to the Interstate Oil and Gas Compact Commission (IGCC), Alta, UT, July 17–19, 2002. http://www.iogcc.state.ok.us/ISSUES/CO2%20Sequestration/co2sequestion.html.
5. Hattenbach, R.P.; Wilson, M.; Brown, K.R. Capture of Carbon Dioxide from Coal Combustion and Its Utilization for Enhanced Oil Recovery. *App. Energy* **1995**, *62*, 217–221.
6. Gulf Exploration and Production Company. *Little Knife Field CO_2 Minitest*, *Billings County, North Dakota*; Final Report for U.S. Department of Energy Contract No. DE-AC21-79MC08383; DOE/MC/08383-45; June 1983.
7. Science Applications Inc. *Feasibility and Economics of By-Product CO_2 Supply for Enhanced Oil Recovery*: Final Report for U.S. Department of Energy Contract No. DE-AT21-78MC08333; Task 36, DE82004815; Jan 1982.
8. Gunter, W.D.; Wong, S.; Cheel, D.B.; Sjostrom, G. Large CO_2 Sinks: Their Role in the Mitigation of Greenhouse Gases from an International, National (Canadian), and Provincial (Alberta) Perspective. *Appl. Energy* **1998**, *61*, 209–227.

9. Timpe, R.C.; Aulich, T.R. *Economic Source Sited Long-Term CO_2 Sequestration*; Draft Final Report for Task 7.2, Activity 2, U.S. Department of Energy Cooperative Agreement No. DE-FC26-98FT40320; June 2002, 13 p.

APPENDIX A

TECHNICAL SECTION OF PCORP PROPOSAL AWARDED TO THE EERC BY DOE

PLAINS CO_2 REDUCTION PARTNERSHIP (PCORP)

TECHNICAL DISCUSSION

1.0 REGIONAL PARTNERSHIP COMPOSITION, TECHNICAL, AND MANAGEMENT CAPABILITIES

1.1 PCORP Program

In response to U.S. Department of Energy (DOE) Program Solicitation DE-PS26-03NT41713, "Regional Carbon Sequestration Partnerships (RCSP) – Phase I," the Energy & Environmental Research Center (EERC) proposes to develop and coordinate the Plains CO_2 Reduction Partnership (PCORP), an international stakeholder-based framework and accompanying methodology designed to identify the major CO_2 sequestration opportunities in the northern Great Plains region, as shown in Figure 1.1, and develop action plans to facilitate small-scale demonstrations of CO_2 sequestration technologies. This region, including North Dakota, South Dakota, Minnesota, Montana, and Wyoming as well as a portion of Canada, was chosen based on a synergy between low-rank (lignite and subbituminous) coal users, geologic sinks, current CO_2 activities, terrestrial sinks, and existing industry collaborations. PCORP will work in concert with DOE RCSP program managers, as well as other RCSP-funded centers and related programs, to fully realize the vision of reducing carbon intensity, increased efficiency, and carbon sequestration

Figure 1.1. PCORP region

expressed in the "Carbon Sequestration Technology Roadmap and Program Plan" (1). PCORP will work to strengthen and expand its membership and technical base over the course of the program, and all activities will be conducted in consideration of affordably meeting U.S. energy demand and environmental concerns.

As shown in Figure 1.2, the goals of this program will be implemented through a management task and four performance tasks using a three-step approach. The PCORP proposal features a management task (Task 1) and four technical tasks (Tasks 2, 3, 4, and 5) in a three-step approach. Step 1 characterizes technical issues and the public's understanding and attitudes concerning CO_2 sequestration, including development of a database on sources, sinks, separation and transportation options, regulatory permitting requirements, and environmental benefits and risks. Step 2 identifies regional opportunities for sequestration and informs the public about options and risk. Step 3 develops a detailed action plan for implementing demonstration projects

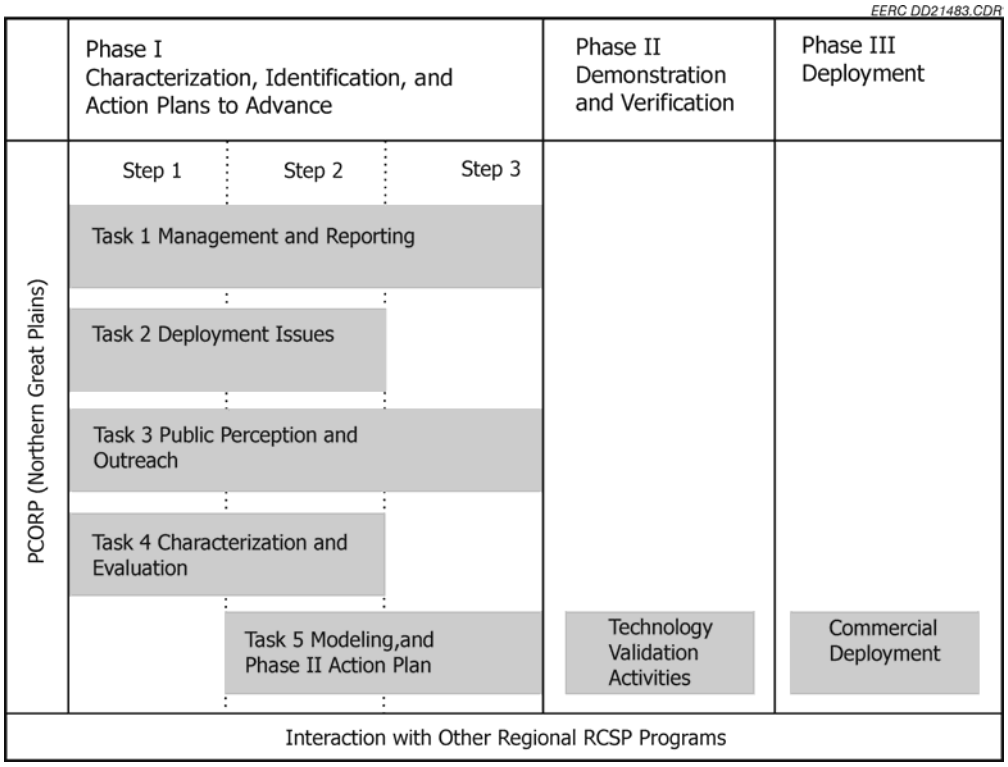

Figure 1.2. – PCORP project in the context of DOE's three-phase RCSP program.

in the PCORP region. The PCORP partners will contribute over the life of the project through working groups that are designated to focus on key topical areas. The EERC will manage and coordinate all project activities to ensure effective and timely reporting to DOE, collaboration with other RSCP programs, and outreach to the public and the technical community.

1.2 PCORP Team

As shown in Table 1.1, PCORP features a diverse, multipartner team under EERC leadership that brings together the key government, private sector, technical, and outreach groups needed to undertake the activities in the four performance tasks. The PCORP team is well suited to assess the regional baseline and infrastructure and to involve stakeholders in developing action plans for Phase II. The PCORP team includes 1) industry sponsors that provide cost share and serve as advisors; 2) research partners that are funded under the PCORP venture; and 3) collaborators that, in most cases, provide in-kind support. The industry sponsors have significant and active operations in all five states of the region. The knowledge base, expertise, and hands-on experience of the PCORP research team encompass the entire region.

Table 1.1. PCORP Team

Industry Sponsors	Research Partners	Collaborators
Basin Electric Power Cooperative	EERC	Western Governors' Association
Dakota Gasification Company	Dakota Gasification Company	Amerada Hess Corporation
Montana-Dakota Utilities Co.	Nexant-Bechtel	Environment Canada
Otter Tail Power Company	North Dakota State University	Interstate Oil and Gas Compact Commission
North Dakota Industrial Commission (NDIC)	Prairie Public Television	Petroleum Technology Transfer Council
Great River Energy	Fisher Oil and Gas	NDIC Oil and Gas Division
		North Dakota Geological Survey
		Minnesota Pollution Control Agency
		North Dakota Department of Health
		Montana Department of Environmental Quality

1.3 PCORP Facilities and Capabilities

The EERC and its PCORP partners bring a unique combination of capabilities and facilities to the PCORP project. The EERC's 210,000 square feet of laboratory, technology demonstration, and office space, located on the southeast corner of the University of North Dakota (UND) campus, house state-of-the-art facilities for analysis, fabrication, and laboratory

to pilot-scale testing and verification. All facilities are available for PCORP and RCSP Phase II activities. In addition, the EERC has the facilities, equipment, and experienced personnel to undertake 1) relational database design, 2) geographic information system (GIS) programming, 3) database applications and decision support tools, and 4) predictive modeling. PCORP's industrial sponsors and collaborative partners have sites and facilities that could be used for the demonstration of CO_2 separation, transportation and capture technologies, and indirect and direct (disposal and value-added) sequestration during RCSP Phase II activities.

1.4 EERC Credentials

The EERC has the proven ability to develop and lead multiyear, multidisciplinary, multiclient programs, including many public–private and stakeholder-based partnerships like PCORP. The EERC was established in 1949 as a federal research facility under the U.S. Bureau of Mines and later became the lead laboratory for low-rank coals under DOE. The center was defederalized in 1983 and became a business unit of UND. The EERC currently has an annual budget of $20 million, covering 241 contracts, three quarters of which are private sector clients. In the last 15 years, the EERC has worked with over 720 clients in all 50 states and in 47 countries. The EERC's multidisciplinary staff of more than 250 has maintained its leading role in coal research and has expanded its expertise and partnerships in a broad spectrum of energy and environmental programs. The EERC has successfully completed projects involving geological characterization of subsurface resources, experimental design, analytical methods development, groundwater quality, biomass-based energy, advanced power systems, atmospheric emission controls, reclamation of disturbed lands, disposal and value-added waste management, disposal site characterization, site remediation for oil and gas, cleanup of the federal weapons complex and industry sites, and training activities from local to international scope.

The EERC's success in effectively serving a broad client base has been supported by its long-standing partnership with DOE through the National Energy Technology Laboratory (NETL). Examples of the successful partnership include the Fossil Energy Cooperative Agreement (1983 to present), the Environmental Management Cooperative Agreement (1985 to present), the Biomass Cooperative Agreement (2000 to present), and projects involving industry–government partnerships under the Jointly Sponsored Research Program (1983 to present), which has attracted more than $30 million of industrial cash support. The EERC has projects and strong working relationships with a number of other state and federal agencies including the U.S. Department of Defense, U.S. Department of the Interior, U.S. Environmental Protection Agency (EPA), U.S. Department of Agriculture, U.S. Geological Survey, and Agency for International Development.

1.5 PCORP Structure

PCORP is structured to ensure optimal input by diverse stakeholders, to function in a practical and cost-effective manner, and to deliver credible, timely results. As shown in Figure 1.3, the PCORP organization is built around four technical tasks (Tasks 2–5). Each task has an EERC lead and is supported by one or more working groups made up of partners and other stakeholders and focused on key topics or subtasks. Leads for the working groups are either EERC personnel or funded PCORP partners. Mr. Thomas Erickson, EERC Associate Director for Research, will serve as Project Manager for PCORP, with input on program direction through the PCORP Advisory Group, and will also serve as the principal point of contact between PCORP and the NETL Program Managers. He will have overall responsibility for the EERC PCORP contract and will interface regularly with task leaders and EERC senior management. He will be responsible for regular reporting to NETL program management, timely dissemination of

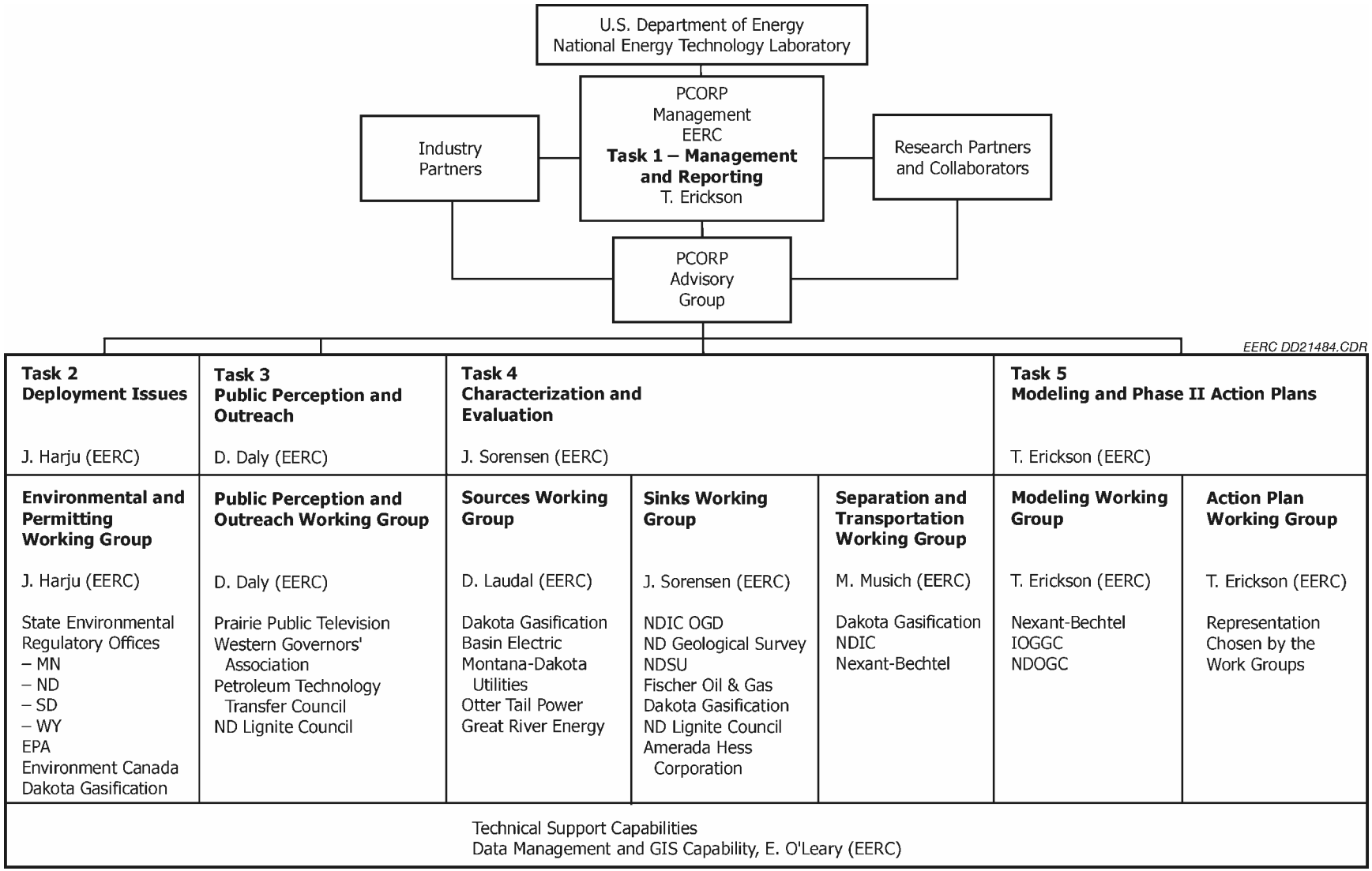

Figure 1.3 PCORP management diagram.

information to the CO_2 sequestration community, and coordination with other partnerships developed under DOE's RCSP program. Leads for the four performance tasks will ensure the progress of the working groups and timely completion of milestones, including program deliverables.

The EERC's contracts and accounting groups will oversee financial and contractual matters. The EERC's data management group will act as the central repository for information, develop and maintain databases and GIS analysis tools, and develop appropriate reports. The EERC's Quality Assurance/Quality Control (QA/QC) staff will ensure that protocols are appropriate and that the results meet the EERC's highest standards. The EERC's report preparation group, including editors, word-processing staff, and graphics personnel, will ensure high-quality report products.

1.6 Key Personnel

Key personnel for PCORP include select administrative and technical staff from all of the research partners, representing a broad range of scientific and engineering disciplines and real-world experience. Relevant EERC expertise includes project management; design, procurement, fabrication, installation, and testing of conventional and advanced systems for energy conversion and emissions sampling and control; data management and GIS; geological characterization and assessment; systems engineering; and public outreach. The PCORP partners bring technical expertise in sources, systems, permitting and regulations, transportation, CO_2 sequestration (including value-added applications), and outreach.

Table 1.3 profiles the expertise and project roles for partners and collaborators on the PCORP team. Table 1.4 profiles key personnel in terms of the expertise needed to fulfill DOE's

Table 1.3. Summary of the Qualifications and Responsibilities for Key PCORP Organizations

			Task 1	Task 4			Task 2	Task 3	Task 5	
Role	**Organization**	**Expertise/Capability**	**Mgt., Reporting**	**Source**	**Sink**	**CO_2 Separation and Transport**	**Regulatory Issues**	**Public Outreach**	**Technology Assessment**	**Action Plans**
Project Management	EERC	Management of multipartner, multidisciplinary research, development, and commercialization projects; stakeholder-based consortia. Multidisciplinary staff of over 250 with expertise in coal-fired energy systems, energy environmental issues, technology development, verification and deployment, data management, GIS, and public outreach and education Experienced staff and capabilities for contract management, accounting, report preparation, public relations and outreach, workshops and meetings, award-winning Web site, and graphics department	P	P	P	P	P	P	P	P
Research Partners	DGC	CO_2 separation from coal gasification process; CO_2 transportation; CO_2 sequestration project development and implementation; candidate sites for technology testing and verification (one of four sources of anthropogenic CO_2 with CO_2 stream currently used in a CO_2–EOR sequestration project in the United States [Weyburn project])		S	S	P	S		S	S
	Fisher Oil and Gas	Regional geology, enhanced oil and gas recovery, injection issues, risk assessment			P		S		S	S
	Nexant-Bechtel	Technical expertise in CO_2 separation and sequestration and technical and efficiency issues.				P	S		P	S
	North Dakota State University	Technical expertise agricultural practices, issues, policy, and terrestrial CO_2 sequestration strategies			P		S		S	S
	Prairie Public Television	Television coverage for entire PCORP region, key audience share, video production and distribution, gateway to other media sectors						P		
Industrial Sponsors	Basin Electric Power Cooperative, DGC, Montana-Dakota Utilities, Otter Tail Power, NDIC, Great River Energy	Candidate sites for technology testing and verification activities, facilitated technology transfer, input from key stakeholders on project direction and implementation		S			S	S	S	S
Collab-orating Partners	State, provincial, and federal regulatory agencies; Western Governors' Association; Petroleum Technology Transfer Council; Amerada Hess, Environment Canada	Permitting and regulatory issues at the state, provincial and federal level, environmental risk assessment			S		P	S	S	S
P=primary role; S=secondary role										

Table 1.4. Summary of Expertise of Key PCORP Personnel

Name	Organization	Management of Large Multidisciplinary Programs	Environmental Policy, Permitting, and Regulations	CO_2 Chemistry and Science	Geological Sequestration	Terrestrial Sequestration	Power Systems/Power Industry	Oil and Gas Industry	GIS/Data Management	Education and Outreach	Emissions Control Technologies	Site Characterization/Site Assessment	**Percentage of Time on Project**
Daly, D.	EERC								X	X			21
Erickson, T.	EERC	X					X			X	X		36
Evans, J.	EERC	X	X					X	X			X	5
Fisher, D.	Fisher Oil and Gas				X			X				X	20
Faller, T.	North Dakota State University (NDSU)			X		X							8
Harju, J.	EERC	X	X		X			X				X	12
Hawthorne, S.	EERC			X				X				X	3
Laudal, D.	EERC						X				X		17
Leistritz, L.	NDSU		X			X							9
Lukes, A.	DGC				X			X					2
Musich, M.	EERC						X				X		29
Nelson, C.	EERC				X			X				X	4
O'Leary, E.	EERC								X				13
Peck, W.	EERC								X				15
Ruby, J.	Nexant-Bechtel	X					X				X		10
Sondreal, E.	EERC						X				X		8
Sorensen, J.	EERC	X	X		X			X				X	30
Steadman, E.	EERC	X								X			34
Weber, G.	EERC	X					X				X		13

project criteria and gives the percentage of time for each person. Detailed resumes for these personnel are included in File 4.

1.7 Reporting and Technology Transfer

As PCORP lead, the EERC will have the primary responsibility for reporting to DOE Project Managers and the CO_2 sequestration community, including sequestration centers in other regions funded under DOE's RCSP program. This will be accomplished under Task 1 (Management, Reporting, and Technical Outreach) as follows: 1) The EERC will organize (a) a project kickoff meeting involving key NETL personnel and funded collaborating partners, (b) two interim meetings that will include visits to active or potential CO_2 sequestration project sites in the region (e.g., Dakota Gasification Company [DGC]–EnCana Weyburn field sites), and (c) a wrap-up meeting at the end of the 2-year Phase I contract period. 2) The EERC will take the lead in fulfilling the contractual requirements for periodic reporting, including monthly highlights, quarterly reports, annual reports, and the summary final report. 3) The EERC will ensure regular communication and information sharing with the CO_2 sequestration community. 4) Papers will be presented at technical meetings, and public information will be disseminated through PCORP fact sheets and the EERC Web site. All PCORP products will give appropriate credit to DOE, other sponsoring groups, and PCORP partners.

2.0 METHODOLOGIES TO IDENTIFY AND ADDRESS CARBON SEQUESTRATION ISSUES

2.1 Introduction

Reduction of CO_2 emissions through sequestration requires a long-term commitment that will involve significant monetary and technical resources over the coming decades. Successful sequestration programs depend not only on the knowledge of sinks, sources, and other technical issues, but also on an understanding of the potential effects of sequestration on the environment

and the regulatory and permitting framework, and on societal support from an informed public. This section describes an approach for characterizing these environmental, permitting, and societal components (Task 2) and for ensuring an informed public, including educators, the business community, and decision makers (Task 3).

2.2 Environmental Efficacy and Permitting Requirements

The consideration of environmental and permitting issues in Task 2 will be coordinated with activities in Task 5 involving the identification of regional opportunities for sequestration and assessment of technology demonstration options. After necessary background information has been obtained, the EERC will bring key stakeholders together in working groups to take part in structured, focused workshops on environmental and permitting issues. The Year 1 workshop for the environmental efficacy working group will focus on 1) potential environmental risks and infrastructure requirements such as transportation, construction, and drilling; 2) monitoring and verification protocols; and 3) review of methodologies for life cycle assessments. For the permitting working group, the Year 1 workshop will focus on 1) current and pending regulations and future regulatory issues and 2) regulatory and permitting barriers to the deployment of sequestration technologies.

To support working group activities, PCORP will develop briefing books and agendas, provide facilitators, and compile workshop results. Workshop participants will include PCORP partners, regional stakeholders, outside experts, and representatives of the public, as appropriate. PCORP will use the workshop as a venue to solicit input from stakeholders, identify priority issues, develop plans for resolving issues, assign action items, and review and discuss demonstration action plans. Research partners, industrial partners, and collaborators will provide technical input and review workshop products for accuracy. Deliverables will include briefing

materials, final reports from each workshop, and workshop evaluation forms. Final reports will be reviewed by DOE managers and by other RCSP centers, as directed by DOE management. These activities will also draw on the characterization data for sources, sinks, separation, and transportation technologies.

In considering geologic sequestration, for example, the working groups will review information on existing disposal and enhanced oil recovery (EOR) projects, including the DGC–Weyburn CO_2–EOR project in the Williston Basin and the process under way for CO_2-driven enhanced coalbed methane recovery (ECBMR) in the Powder River Basin. The working group will also consider findings from general environmental efficacy analyses under way by the Interstate Oil and Gas Compact Commission (IOGCC) and other groups and life cycle information from projects in other areas of the country (e.g., Permian Basin).

Year 2 workshops will build on the information from the Year 1 workshop to provide input to the modeling and action plan development under Task 5.

2.3 Mechanisms for Public Education and Involvement

The PCORP public perception and outreach working group, shown in Figure 1.3, will be drawn from the Western Governors' Association, Prairie Public Television, grassroots groups, industry groups, and the EERC. This group will gauge public perception on sequestration and use that information to lay the groundwork for an effective outreach to inform the public of the capabilities and benefits of the partnership. The group will also develop means to engage the public in stakeholder activities and will provide initial approval of all outreach materials, with final review by DOE, as appropriate.

Based on preliminary discussions with outreach partners, PCORP will gauge the public's understanding of global climate change mitigation through organized focus groups prior to the

Year 1 workshop, prior to the Year 2 workshop, and at the end of the project. These focus groups will provide input to guide public outreach and an assessment of the effectiveness of the outreach efforts.

The Year 1 workshop will focus on developing a basic fact sheet describing global climate change issues, PCORP and its role in DOE's overall sequestration mission, and the basics of CO_2 sequestration. This fact sheet will form the basis for postings on the EERC Web site, presentations and displays at PCORP meetings and public events, informational mailings to major grassroots groups in the region, and newspaper pieces in the major regional newspapers. PCORP personnel will work with other groups in the CO_2 sequestration community, including those at other DOE centers, to ensure consistency in the message to the public and will share its experience and materials, including video and Web site materials, with other groups in the RCSP program, as appropriate.

The Year 2 workshop will provide input for a 30-minute informational video, "PCORP – Reducing CO_2 in the Northern Great Plains," to be developed by Prairie Public Television. This video will inform the public and decision makers about CO_2 sequestration, DOE's RSCP programs, the regional PCORP program, and sequestration opportunities in the region. The video will be shown across the Prairie Public viewing area and will be targeted at the adult population (the viewing area corresponds to the PCORP region). The Year 2 workshop will also provide input to curriculum development for the North Dakota Lignite Research Council and various petroleum councils, to annual teacher workshops, and to fact sheets on regional opportunities and demonstration projects. Information from workshops will support development of Web materials, print and broadcast media, and the outreach portion of the action plan for Phase II.

3.0 METHODOLOGIES TO CHARACTERIZE THE PCORP REGION AND EVALUATE CO_2 SEQUESTRATION OPPORTUNITIES

3.1 Introduction

Successful CO_2 sequestration projects, including value-added projects, require appropriate combinations of sources, separation technologies, sinks, and transportation infrastructure to move the CO_2 from source to sink. This section describes the PCORP region and its attributes; the approach that will be taken to characterize the PCORP region's sources, sinks, and infrastructure; and an approach for data management (Task 4). This section also describes the approach for developing modeling criteria needed to determine major opportunities for sequestration in the region and the approach for action plan development (Task 5).

3.2 PCORP Region Definition and Attributes

As shown in Figure 1.1, the PCORP region includes North Dakota, South Dakota, Minnesota, and portions of Montana and Wyoming in the United States, as well as portions of the Canadian provinces of Saskatchewan and Manitoba. The PCORP region was defined on the basis of similarities in large stationary CO_2 sources, similarities in geologic and terrestrial CO_2 sinks, transport considerations for direct CO_2 sequestration, and the presence of two major value-added, anthropogenic CO_2–EOR sequestration projects. This combination of regional attributes, detailed below, makes the PCORP region well suited to meet DOE's criteria for the RCSP – Phase I program.

3.2.1 Sources. As shown in Table 3.1, the U.S. portion of the PCORP region produced 67.63 MMTCE (million metric tons carbon equivalent) of anthropogenic CO_2 in 1999, about 4.6% of the U.S. total. Major stationary sources (utility and industrial) contributed 44.86 MMTCE, or two-thirds, of the 67.63-MMTCE total for the region. The utility sector,

Table 3.1. Summary of 1999 CO_2 Emissions in the U.S. Portion of the PCORP Region (2)

State	Utility	Industrial	Other Stationary	Transportation	State Total
MN	8.00	3.72	3.75	9.56	25.02
MT	4.36	1.43	0.54	2.04	8.37
ND	8.53	3.19	0.55	1.55	13.82
SD	0.98	0.58	0.47	1.60	3.63
WY	11.37	2.70	0.45	2.26	16.79
PCORP Total	33.24	11.62	5.76	22.77	67.63
U.S. Total					1477.32

including the 34 sources of greater than 100-MW capacities, contributes 33.24 MMTCE, representing half of the CO_2 emissions for the region. The industrial sector, including 27 ethanol facilities (3), accounted for an additional 11.62 MMTCE. To meet the President's Global Climate Change Initiative (GCCI) goal, CO_2 emissions in the region would need to be reduced 18% (12.17 MMTCE) by 2012 (see Table 3.2).

3.2.2.1 Geologic Sinks. The PCORP region includes the Williston Basin and the Powder River Basin. Both of these are significant hydrocarbon-producing basins that include significant production from carbonates. These basins have active or planned sequestration projects related to value-added conventional oil or CBM production, as well as recognized potential for sequestration in deep aquifers, exhausted hydrocarbon production units, and unminable coal seams (sink potential is discussed in greater detail in Section 3.5 and Table 3.3). For example, the Williston Basin is one of five U.S. basins that has an active CO_2–EOR project (i.e., DGC–EnCana Weyburn project [4, 5]), a successful demonstration in other conventional oil fields (i.e., the Little Knife Field test by Gulf Oil Exploration and Production [6]), and has more than a dozen candidates evaluated for CO_2–EOR projects (7).

3.2.2.2 Terrestrial Sinks. The semi-arid, rolling grasslands of the plains dominate the western portion of the region and are currently used for grazing and growing small grains, and the forested landscape of the northeast and north offer opportunities for testing and verification of soil and vegetative technologies. Agricultural soils in the PCORP region have the potential to

Table 3.2. Estimated CO_2 Emissions from Coal-Fired Power Plants in and Around the PCORP Region

Coal-Fired Power Plants	Plant State	Fuel	Geologic Province	Annual Utility Emissions By State, MMTCE
Fox Lake	MN	NG	SA	8.0
Clay Boswell	MN	S	SA	
M.L. Hubbard	MN	O	SA	
Black Dog	MN	S	SA	
Blue Lake	MN	S	SA	
High Bridge	MN	S	SA	
Inver Hills	MN	O	SA	
King	MN	S	SA	
Riverside	MN	S	SA	
Sherburne	MN	S	SA	
Colstrip	MT	S	PRB	4.36
JE Corette	MT	S	PRB	
Lewis & Clark	MT	L	WB	
Antelope Valley	ND	L	WB	8.53
Coal Creek	ND	L	WB	
Coyote	ND	L	WB	
Heskett	ND	L	WB	
Leland Olds	ND	L	WB	
Stanton	ND	L	WB	
Young	ND	L	WB	
Ben French	SD	S	WB	0.98
Big Stone	SD	S	WB	
Argo Anson	SD	NG	SA	
Dave Johnson	WY	S	PRB	11.37 (7.2)
Laramie River	WY	S	PRB	
Neil Simpson 1	WY	S	PRB	
Neil Simpson 2	WY	S	PRB	
Osage	WY	S	PRB	
Wyodak	WY	S	PRB	

NG = natural gas; SA = Sioux Arch; S = subbituminous coal; O = oil; PRB = Powder River Basin; L = lignite coal; WB = Williston Basin

take up 0.2 to 0.45 tons of carbon per hectare (e.g., 1.6 MMTCE per year for the 16.2 million ha of arable land in North Dakota) (10). Studies in Canada suggest that the 15 million acres of Minnesota forest area (6.1 million ha) has the capacity to take up about 0.27 MMTCE per year in timber through 2050 (10).

3.2.2 Anthropogenic CO_2–EOR Projects. The PCORP region contains projects involving two of the four U.S. industrial sources of CO_2 and five of the 74 CO_2–EOR projects in the United States and accounts for a significant portion of the 7 MMTY of anthropogenic CO_2 currently used for EOR (6). The Weyburn CO_2–EOR project on the northwest flank of the Williston Basin involves

EnCana and DGC. The US$750 million Weyburn project moves 5000 tons of CO_2 per day by dedicated pipeline from the DGC facility in west-central North Dakota to the Weyburn oil field in southeastern Saskatchewan, Canada. Weyburn is the only CO_2–EOR project utilizing CO_2 from a coal conversion unit and is projected, over its 20-year life, to result in the production of an additional 120 million barrels of oil and the sequestration of 19 million (net) metric tons of CO_2 (5, 11). The LaBarge gas plant, proximal to the PCORP region, would be a candidate for supplying CO_2 for EOR in the Salt Creek field in the Powder River Basin (4).

3.3 Characterization Plan for Sources, Sinks, Separation, and Transportation

Developing knowledge of the character and spatial relationships of sources, sinks and, in the case of direct sequestration, the transportation links between them is basic to developing and assessing approaches to CO_2 sequestration. PCORP will develop this information in Task 4 and then use it to both identify major CO_2 opportunities in the region and develop action plans under Task 5. This information will be shared with the environmental efficacy and permitting working group (Task 2) and be made available as a basis for public outreach under Task 3.

PCORP will undertake this characterization and assessment effort by bringing key stakeholders together in working groups to take part in structured workshops focused on sources, sinks, and transportation issues. In Year 1, the working groups will develop a detailed characterization plan and initiate characterization efforts. In Year 2, the working groups will focus on specific issues needed to identify and facilitate Phase II demonstration projects under Task 5. PCORP will take the lead in this process, developing briefing books and agendas, providing facilitators, and compiling workshop results. Workshop participants will include regional stakeholders, outside experts, and representatives of the public, as appropriate. PCORP will use the workshops as venues to solicit input from stakeholders, identify priority issues,

identify data gaps and means to address gaps, develop detailed action plans to complete characterization activities, assign action items, and review and update action plans. PCORP will take the lead in database and GIS development and report preparation and will provide support for workshop communications, graphics, report preparation, and technical expertise, as appropriate. The research partners, sponsors, and collaborators involved in the working groups will provide technical input and periodically review the report materials, data, and database products. Deliverables will include briefing materials, an action plan, a final report from each working group, database materials, and workshop evaluations. The activity will be undertaken in consultation with DOE management and other RCSP centers and programs, as directed by DOE. PCORP will work with other RCSP centers and DOE Program Managers to develop consistent data survey instruments and data management and report formats. The GIS database and other data products developed by PCORP will be made available to stakeholders through Web pages and other software applications in order to facilitate the evaluation of the feasibility of sequestration technologies with respect to technical application and cost. Along with the populated GIS database, the PCORP final report will contain a comprehensive assessment of CO_2 sources in the region. Specific activities of the working groups and related activities under Task 4 that will lead to detailed information on sources, sinks, and transportation venues are discussed below.

3.3.1 Source Characterization. The source working group will be composed of representatives from utilities, DGC, ethanol facilities, and oil- and gas-processing facilities. The group will characterize the major CO_2 point sources in the PCORP region by reviewing available data for power plants, ethanol facilities, petroleum refiners, and other energy-intensive industries. Data will be collected on a plant-specific basis. Plant owners/operators will be contacted to confirm

and update data and to obtain additional data where needed. Plant visits will be arranged where closer communications are required to fulfill task requirements. Source-screening criteria will include items such as 1) the minimum CO_2 emission level for including a source in one or more scenarios; 2) the proximity of a source to transportation routes, other CO_2 sources, and sequestration site locations; 3) the CO_2 concentration in the emissions and critical considerations for separation and capture, including the state of technology development and costs; 4) plant age, performance efficiency, annual operating hours, and operating cycle; and 5) other plant emissions and pollutants such as acid gases or hazardous air pollutants (HAPs) which might be considered for multiple pollutant control to reduce the cost of CO_2 separation and capture.

3.3.2 Geologic Sink Characterization. The geologic sink working group will include representatives of NDIC Oil and Gas Division, the North Dakota Geological Survey, Fisher Oil and Gas, and Amerada Hess Corporation. Information will be assessed from a variety of sources including the National Coal Resource Data System (NCRDS) maintained by USGS (and locally developed for the EERC, Montana Bureau of Mines and Geology, and Wyoming Geological Survey), NDIC Oil and Gas Division data system, and Wyoming Oil and Gas Conservation Commission data system, as well as information for the Weyburn project in the Williston Basin available from DGC, a PCORP partner. Information from Amerada Hess Corporation, the largest petroleum production operator in the Williston Basin, will also form a key part of this activity.

The team will characterize the major geologic sinks in the Williston and Powder River Basins. General attributes will include formation name, lithology, thickness, depth, structure, fluid chemistry and pressure, and oil and gas production or potential production. For oil and gas production zones, including CBM and conventional oil and gas, additional information will be collected on well number, well location, field name, production to date and ultimate production,

and enhanced oil and gas recovery projects. For water flood and water disposal wells, information will include well designation, field designation, location, injection horizon, formation name, injection volumes, and additional characterization data. Information will also be collected on untapped potential for disposal at depth. These data, including cost information, will be entered into the relational database and GIS, as appropriate, and will be compiled in a report.

3.3.3 Terrestrial Sink Characterization. Carbon in the PCORP region's soils has declined in the past 100 years because of intense cultivation, wind and water erosion, reduced biomass return, grazing, and reduced summer fallow. Activities will focus on near-term, low-cost agricultural practices that increase soil organic matter—conservation tillage (minimum or no till), conservation of cropland to pasture or other perennial vegetation, and planting of cover crops on summer fallow—and increase soil CO_2 uptake from the atmosphere. The working group will determine land use criteria, characterize land use (e.g., major crop and livestock enterprise areas and nonproductive land), provide data to the GIS database, and develop Conservation Reserve Program (CRP) and livestock-grazing scenarios for modeling and assessment under Task 5. The Task 5 model will estimate incentive payments needed to achieve different levels of CO_2 reduction. Open questions regarding the stability of sequestered carbon and verification of offsets in CO_2 emissions will be addressed.

3.3.4 Separation and Transportation Characterization. Candidate technologies for the capture of CO_2 from the primary sources in the PCORP region, particularly coal-fired power plants, will be identified and evaluated. The methods investigated will include processes such as alkanolamine-based chemical absorption, oxy-fuel combustion, and molecular sieve technologies. The benefits of other state-of-the-art clean coal and natural gas-processing technologies will also be examined. This working group will also focus on transportation issues

for direct sequestration (transportation issues for value-added indirect sequestration will be explored under the terrestrial working group), including rail, road, and pipeline. Regional consensus indicates that long-term, large-scale sequestration operations in the region will use dedicated pipelines because of the large gas volumes and gas properties. However, all transportation options warrant evaluation for potential near-term use until the scale of sequestration operations increases substantially.

The working group will collect data on major roads, railways, pipelines, and rights-of-way currently used by railroads, pipelines, water diversion canals, and electricity transmission. Data collection will be limited to major systems that represent transportation options for all parts of the region. The nature of land and mineral rights ownership, including pertinent access and use regulations on public and private lands in the PCORP region, will also be determined.

The team will first prepare a brief conceptual assessment of generic transportation modes. Technical specialists will examine basic issues such as practical limits for the quantities of CO_2 that can be transported, the potential for using existing transportation equipment, and the need for developing new equipment for CO_2 transport. The review includes existing pipelines and vessels mounted on rail and over-the-road vehicles. The assessment will define the range of capability for different modes of transportation. Finally, the available data on transportation systems will be screened to select a set of options for near-term and long-term CO_2 sequestration. The selected data for rail, road, pipeline, and right-of-way systems will be consolidated and entered into the relational database for integration with the CO_2 source and sequestration site data for use in evaluating sequestration scenarios.

3.4 Data Management System

A database management system (DBMS) will be developed for PCORP that integrates new and existing relational databases, GIS, and Web programming to query, analyze, and map data with respect to the character of sources, sinks, and transportation infrastructure as well as environmental and permitting information. These data will be used as a basis for inputs to evaluate major sequestration options and to produce products for public outreach and technical transfer. DBMS applications will be developed for efficient data entry, querying, and reporting. Data sets that contain new geographic features and coverages will be formatted using the USGS standard for digital data so that they can be used in other GIS systems. The database will be integrated into the GIS system and will be accessible to other software applications.

GIS will be used for geospatial analysis and portrayal of the data. GIS will provide the ability to perform both spatial and attribute queries on the underlying data. In addition to the data housed in the DBMS, potential digital geo-referenced data sources include NDGS, NDIC, USGS, EPA, and the Natural Resources Conservation Service. Geospatial analysis of the data will aid in identifying the best candidate areas for CO_2 sequestration. To ensure compatibility and to avoid duplication of effort, PCORP data management activities will be coordinated with DOE management, other RCSP centers, and DOE sequestration database projects such as MIDCARB (12). A Web-based GIS product will be developed that will include text-based and map-based search capabilities.

3.5 Potential Aggregate Amounts of Greenhouse Gas Storage and Value-Added Benefits

Table 3.3 provides estimates of the sequestration potential for the PCORP region based on estimates in the literature and estimates based on published methodologies used in other regions.

3.6 Determining Promising Opportunities for Sequestration

3.6.1 Introduction. Task 5 will develop a model to assess candidate sequestration projects and use the model to identify the most promising candidate projects for sequestration as a basis for implementing demonstrations under Phase II. Developing and evaluating regional sequestration scenarios will require inputs and collaboration from the overall PCORP team. Inputs for the modeling in Task 5 will include data on sinks, sources, and transportation from Task 4; characterization and assessment of environmental and permit project components from Task 2; and societal issues from Task 3. In addition to these inputs, the working groups will obtain modeling in Task 5 will include data on sinks, sources, and transportation from Task 4 societal, environmental, and permitting components from Task 2, and societal issues from Task 3. Additionally, the working groups will obtain information from current sequestration

Table 3.3. Partial Summary of Estimated Near-Term and Ultimate Sequestration Potential in the PCORP Region

Sink	Environmental Impact[1]	Stability and Security[1]	Verifiability[1]	Annual Near-Term Potential (MMTCE)	Ultimate Potential (MMTCE)[3]
Deep Aquifers	Neutral	H	H	–	
Depleted Reservoirs	Neutral	H	H	–	8000[2]
CO_2–EOR Conventional Oil	Neutral	M	H	2.7[3]	
Coal Beds >500' deep	Neutral	H	H	–	2339[4]
CO_2–EOR CMB	Neutral	M	H	–	
Agriculture/Soil	Positive	L-M	L	1.6 (ND only)[5]	–
Forest	Positive	L-M	L	0.2 (MN only)[6]	
Total				4.5	10,339
PCORP 2012 Reduction Target				12.2	12.2
Years of Target Volume Sequestration				0.37 years[7]	847[7] years

1 = based on Gunter et al. (10); 2 = calculation accommodating all mid-depth geologic sequestration by assuming 0.5% pore volume for the estimated total volume of strata from depths of 5000 to 10,000 ft in the Powder River and Williston Basins (i.e., approximate strata volume = 306,000 cubic miles) and physical conditions at 10,000 ft of depth; 3 = estimate for annual conventional CO_2–EOR assumes continued activity at Weyburn field in the Williston Basin (0.5 MMTCE/yr over 20 years DGC and EnCana [5]); full sequestration of the CO_2 volume carried by the proposed 250 MMSCF/day CO_2 pipeline to the Salt Creek Field in the Powder River Basin (1.4 MMTCE/yr; ExonMobil LaBarge gas-processing facility and Anadarko Petroleum); and implementation of other conventional CO_2–EOR project possible in the region (e.g. the preliminary assessment in [7] identified over a dozen potential projects with a combined total of approximately 0.82 MMTCF/yr over 15 years for the Williston Basin; 4 = calculation (accommodating both disposal and coalbed methane EOR based on information from Strickler and Flores (8) that is, 400 standard cubic feet CO_2 sequestration capacity per ton of subbituminous coal at a depth 500 feet on a dry, ash free basis, for a 650 billion ton unrecoverable coal resource (combined total of Williston Basin lignite and Powder River Basin (subbituminous); 5 = application of sustainable cropping practices to the 20.4 million harvested acres in North Dakota based on 0.08 tons of carbon sequestered per acre per year calculated for Alberta cropland (10); 6 = sequestration capacity for 16.7 million acres of Minnesota forest based on a sequestration potential of 0.01 tons of carbon sequestered per acre per year for Alberta forests; 7 = equivalent years of sequestration for the approximately 12.2 MMTCE of annual emissions needed to meet the 18% reduction in CO_2 emissions for 2012.

activities and will consult with DOE management, other RCSP centers, and relevant DOE projects.

Team members working on data tasks will provide information on an ongoing basis to other groups performing engineering and scientific calculations and, in return, receive feedback to the database construction process—including results of calculations, new data requirements, and assumptions made for missing data elements in database calculations. The combined effort will result in a database and modeling capability that provides for the definition and inspection of a wide range of scenarios suited to regional conditions.

3.6.2 Preliminary Screening. Preliminary screening of the major components involved in sequestration scenarios will ensure consideration of realistic alternatives and set practical limits on the number and types of scenarios to be evaluated. The screening matrix will consider items such as 1) source characterization—quantities of gas produced, gas properties, capture technologies, current and future feasibility and cost, location relative to the other sequestration components, and surrounding social, political, and environmental conditions; 2) transportation options—a methodology may, for example, subdivide the PCORP region into several areas and perform engineering evaluations of transport capacities, rail extensions, and right-of-way opportunities for pipelines and consider limiting factors from life cycle assessments; 3) sequestration site—storage capacity, location vis-á-vis the sources, transportation, and other issues (e.g., enhanced oil/gas recovery, long-term leakage, and the surroundings whether urban, rural, or industrial).

The preliminary screening will examine combinations of parameters for sources, transportation, and sequestration and related timing issues such as when improved separation and capture technology might become available, when new and more efficient plants will be built,

and schedules for plant retrofits and pipeline construction. Technology scenarios and sites for research and development will be identified. The overall assessment method will address a large number of issues including environmental risk, technical feasibility and availability, cost and economics, life cycle assessment impacts, and social and political factors. The objective is to construct a practical modeling methodology that will be kept manageable by screening and will be guided by discussions with other RCSP groups.

3.6.3 Scenario Assessment Model and Methodology. The proposed modeling methodology will be computer-based and will use commercial spreadsheet software that can interact with the database and its software. The assessment model will be relatively simple, will accommodate large amounts of data and a practical number of scenarios, and will provide results that are easily comprehensible. The model team will assess and prepare multiple options to display and print results, make comparisons of rankings, test for sensitivities, and otherwise simulate "what if" conditions.

The scenario assessment methodology will be used to rank projects with respect to the three phases of the DOE RCSP framework – that is, RCSP Phase II, involving relatively small-scale tests, followed by larger pilot programs of about a million tons per year in Phase III. Phase III will cover the period from the end of Phase II testing to 10 years in the future, or about 2015. Longer periods will also be evaluated using scenario data out to ca. 50 years. This time line allows for examining existing and developing technologies and eventual filling of available sequestration sites.

4.0 PROJECT PLAN AND TECHNICAL APPROACH

4.1 Objectives

The goal of PCORP is to develop and implement a partnership framework in the northern Great Plains region that can identify cost-effective CO_2 sequestration systems for the region and then facilitate and manage the testing of these technologies. These systems will be used as a basis for eventual large-scale demonstration and deployment of the sequestration technologies in accordance with the President's goal to reduce CO_2 by at least 18% by the year 2012 while simultaneously enhancing the economy. Phase I objectives include the evaluation of options and potential opportunities for regional CO_2 sequestration and the development of action plans for the implementation of small-scale validation testing of the most promising technologies. PCORP activities will also promote the implementation of technology for the capture, transport, and storage of anthropogenic fossil fuel CO_2 emissions across the United States. Table 4.1 describes the tasks and deliverables. Table 4.2 shows the labor breakdown for each task.

4.2 Scope of Work

PCORP will accomplish the DOE project objectives by 1) characterizing the region with respect to CO_2 sources, sinks, and storage options and matching sources and sinks; 2) identifying and addressing issues for technology deployment; 3) developing public involvement and educational programs; 4) identifying the most promising capture, sequestration, and transport options; 5) preparing action plans for implementation and technology validation activities; and 6) providing efficient and effective management and reporting.

4.3 Tasks to Be Performed

PCORP features a management task (Task 1) and four performance tasks (Tasks 2–5) in a three-step process as profiled below.

Table 4.1. Summary of Proposal Tasks and Deliverables

EERC Proposal Attribute	EERC Program Deliverable
Task 1 – Management, Reporting, Technical Communication	
Approach featuring three subtasks that address initial organization and formalization of the PCORP structure, PCORP coordination, project management and contractual reporting, and outreach to the CO_2 sequestration technical community.	• Abstracts, presentations, and papers for a minimum of four technical meetings. • Technical fact sheets on regional sources, sinks, and candidate sequestration projects. • Technical Web pages for the EERC Web site and/or a national Web site. • Midterm and summary statements on RCSP approach by PCORP Advisory Group.
Task 2 – Technology Deployment Issues	
Approach featuring five subtasks undertaken through the environmental efficacy and permitting working groups, focused on the identification and resolution of technology deployment issues for the PCORP region with respect to permitting, environmental efficacy and monitoring, and verification as well as inputs for scenario modeling and action plan development for Phase II activities.	• Annual Workshop Materials, including briefing materials, workbooks, and evaluation forms. • Detailed work plans for Year 1 and Year 2 activities developed by the working groups, including a listing of key gaps and barriers and a strategy for addressing these items • Criteria lists • Final reports from each working group.
Task 3 – Public Outreach and Education	
Approach featuring seven subtasks undertaken through the public perception and outreach working group and focused on gauging public perceptions and understanding of global warming and CO_2 sequestration as a basis for the development of public outreach materials including fact sheets, educational curricula, and video pieces as well as inputs for scenario modeling and action plan development for Phase II activities.	• Logo and outreach product format. • Focus group materials including questionnaires and statistical assessments. • Annual workshop materials, including briefing materials, workbooks, and evaluation forms. • Semitechnical fact sheets on CO_2 and sequestration, PCORP and sequestration, regional sequestration opportunities, proposed sequestration projects. • Web pages for the EERC Web site based on these fact sheets • Newspaper articles for major regional newspapers based on the fact sheets • 30-minute video on the PCORP program and sequestration options that will air on television and other venues • 10-minute video pieces on specific sequestration project opportunities in the PCORP region • Curriculum development packet for use in K–12 teacher training venues
Task 4 – Regional Characterization	
Approach featuring five subtasks undertaken by three working groups (sources, sinks, and separation and transportation) and designed to assess sources, sinks, options for CO_2 separation, and CO_2 transportation options and to develop inputs for scenario modeling and action plan development for Phase II activities.	• Annual Workshop Materials, including briefing materials, workbooks, and evaluation forms. • Detailed work plans for Year 1 and Year 2 activities developed by the working groups including a listing of knowledge gaps and barriers and a strategy for addressing these gaps and barriers. Screening and modeling criteria lists final reports from each working group relational database. • Inputs for sources, sinks, transportation, for screening, modeling, and Action Plans.
Task 5 – Data Management, Technology Selection, and Action Plans	
Approach featuring four subtasks undertaken by the modeling and action plan working groups leading to the development of a relational database management system, the identification of most promising scenarios for testing and verification, and the development of action plans for the projects to be undertaken under RCSP Phase II.	• Relational DBMS. • GIS system for geospatial analysis and display of DBMS contents. • Programming to allow use of DBMS and GIS on the Web. • Annual workshop materials including briefing materials, workbooks, and evaluation forms. • Detailed work plans for Year 1 and Year 2 activities. • Summary screening and modeling criteria lists. • Final reports from each working group. • Summary list of screening and modeling criteria. • Screening formats and results. • Modeling methodology and results. • Action plans for three demonstration and verification projects.

Table 4.2 Labor Hours and Justification

EERC	Task 1	Task 2	Task 3	Task 4	Task 5	Total
Erickson, T., Project Manager	400	120	80	80	800	1480
Harju, J., Principal Investigator	200	–	–	120	180	500
Daly, D., Principal Investigator	–	120	500	–	260	880
Sorensen, J., Res. Sci./Eng.	–	240	–	600	400	1240
Hawthorne, S., Res. Sci./Eng.	50	–	–	75	–	125
Nelson, C., Res. Sci./Eng.	–	60	–	50	50	160
Evans, J., Res. Sci./Eng.	40	50	30	40	40	200
Laudal, D., Res. Sci./Eng.	–	–	–	320	400	720
O'Leary, E., Res. Sci./Eng.	–	–	–	100	420	520
Weber, G., Res. Sci./Eng.	–	200	–	–	320	520
Musich, M., Res. Sci./Eng.	–	800	–	–	400	1200
Senior Management	421	–	–	–	–	421
Research Scientist/Engineer	826	2000	1052	761	3397	8036
Research Technician	701	–	–	–	–	701
Technical Support Services	200	–	300	–	250	750
Total	2838	3590	1962	2146	6917	17,453
NDSU						
HREC Agronomist	–	210	–	210	–	420
HREC Technician	–	210	–	210	–	420
HREC Laborer	–	210	–	210	–	420
NDSU Soils Grad. Student	–	2000	–	2000	–	4000
NDSU AAE Res. Sci./Assoc.	–	–	–	700	–	700
Total	–	2630	–	3330	–	5960
Dakota Gasification						
Lukes, A., Lead Engineer	–	–	48	–	–	48
Engineer	–	–	48	–	–	48
Total	–	–	96	–	–	96
Nexant-Bechtel						
Project Engineer	–	468	–	–	–	468
Process Design Engineer	–	40	–	–	–	40
Cost Engineer	–	60	–	–	–	60
Engineering Specialists	–	100	–	–	–	100
Total	–	668	–	–	–	668
Prairie Public Television						
Producer	–	–	804	–	–	804
Videographer/Editor	–	–	550	–	–	550
Grip/Assistant	–	–	144	–	–	144
Graphic Artist	–	–	55	–	–	55
Total	–	–	1553	–		1553

4.3.1 Task 1 – Management, Reporting and Technical Outreach. Task 1, composed of three subtasks, will continue for the duration of the project and will consist of initial organization and formalization of the PCORP structure, PCORP coordination, project management and contractual reporting, and outreach to the CO_2 sequestration technical community. **Subtask 1.1 –**

Organization and Coordination – will ensure that PCORP is appropriately organized, that activities are coordinated, that the program draws fully on the diverse assets represented by the PCORP partnership, and ensure that regular and effective communication between DOE RCSP program management the PCORP Advisory Group, task managers, and working group leads. **Subtask 1.2 – Management and Reporting –** will ensure timely completion of milestones, the quality of deliverables, the appropriate allocation of resources and personnel, accurate and timely project reports as directed in the "Federal Assistance Reporting Checklist," and effective communication between PCORP and DOE management. This task also includes meetings (semiannual or as otherwise directed) between representatives of the PCORP Advisory Group, the PCORP management team, and DOE Project Managers. **Subtask 1.3 – Technical Outreach –** will provide PCORP visibility in the CO_2 sequestration community and timely dissemination of PCORP's technical results through attendance and presentations at two technical meetings per year, distribution of technical support materials, posting of technical materials on the Web, and regular communication with other RCSP groups and related programs.

4.3.2. Task 2 – Technology Deployment Issues. Task 2, containing five subtasks undertaken through the environmental efficacy and permitting working groups, will identify and evaluate technology deployment issues for the PCORP region. **Subtask 2.1 – Task Management and Support –** provides for the development of a detailed task work plan, coordination of working group activities, development of materials for annual workshops, reporting to the PCORP manager and the PCORP Advisory Group, and preparation of contractual documents. **Subtask 2.2 – Safety, Regulatory, and Permitting –** will focus on the identification and resolution of safety, regulatory and permitting issues. **Subtask 2.3 – Ecosystem Considerations –** will evaluate the environmental effects of sequestration options and will develop an environmental

baseline and assessments for specific sequestration options. **Subtask 2.4 – PCORP Project Monitoring and Verification Plan –** will assess monitoring and verification strategies for use with sequestration scenarios in the region. **Subtask 2.5 – Inputs for Modeling and Action Plans –** will formalize inputs for the DBMS criteria for screening and modeling, and information for the action plans for Phase II.

4.3.3 Task 3 – Public Perception and Outreach. Task 3, containing seven subtasks undertaken through the public perception and outreach working group, is designed to gauge public understanding of climate change issues and CO_2 sequestration as a basis for developing and implementing a public outreach program featuring educational materials and video productions. **Subtask 3.1 – Management and Support** – will coordinate working group activities, develop materials for annual workshops, prepare reports for PCORP management, and prepare contractual documents. **Subtask 3.2 – Public Perception Assessments** – will gauge public perception and understanding of key issues at three points during the PCORP project to aid in outreach program development. **Subtask 3.3 – Fact Sheets –** will develop fact sheets that will serve as the basis for other outreach materials and ensure a consistent outreach message. **Subtask 3.4 – Fact Sheets –** will provide consistent, factual reporting on sequestration policies. **Subtask 3.5 – PCORP Web Pages** – will develop Web pages for posting on the EERC's Web site and will provide for links with other pertinent sites. **Subtask 3.6 – PCORP Education Materials** – will develop and dissemination curricula materials through established regional programs. **Subtask 3.7 – Video Development –** Prairie Public Television will develop a 30-minute informational video and three 10-minute videos focused on Phase II projects that will be aired on television and used in other outreach venues. **Subtask 3.8 – Input for Technology**

Selection and Action Plans – will formalize criteria for screening and modeling and provide input for the action plans for Phase II activities.

4.3.4. Task 4 – Regional Characterization. Task 4 will be accomplished through three working groups (sources, sinks, and separation and transportation) that will assess sources, sinks, options for CO_2 separation, and CO_2 transportation options and will develop inputs for scenario modeling and action plan development for Phase II activities. **Subtask 4.1 – Task Management and Support –** provides for the coordination of working group activities, development of materials for annual workshops, reporting to the PCORP management, and preparation of contractual documents. **Subtask 4.2 – Characterization of PCORP Regional CO_2 Sources –** will characterize significant sources of CO_2 emissions including the 29 coal-fired power plants in the region (greater than 100 MW), the DGC facility, and other major industrial sources such as the 27 ethanol production and gas-processing facilities. **Subtask 4.3 – Characterization of PCORP Regional CO_2 Sinks** – involving the sink working group will characterize regional geologic and terrestrial sinks and assess their characteristics with respect to potential CO_2 sequestration options, including value-added options such as enhanced production of oil and gas resources. **Subtask 4.4 – Characterization of PCORP Infrastructure –** involving the separation and transportation working group will characterize the existing infrastructure and quantifying the needs for additional infrastructure to support deployment of CO_2 sequestration. **Subtask 4.5 – Input for Task 5 –** involves representatives of several working groups collaborating to formalize criteria for screening and modeling and to provide input for the Action Plans in support of Phase II activities.

4.3.5 Task 5 – Technology Selection and Action Plans. Task 5, undertaken by the modeling and action plan working groups, will identify promising capture, transport, and sequestration options

through a screening and modeling activity followed by the development of action plans for the projects to be undertaken under RCSP Phase II. In addition, Task 5 includes the development of a DBMS to house data for use in assessment and modeling activities. **Subtask 5.1 – Task Management and Support –** provides for the development of a detailed task work plan, coordination of working group activities, development of materials for annual workshops, reporting to the PCORP management and the preparation of contractual documents. **Subtask 5.2 – Development of Data Management System –** will develop a DBMS that integrates new and existing regional databases, GIS, and Web programming to query, analyze, and map data with respect to the character and economics of sources, sinks, and infrastructure issues (all in Task 4), environmental and permitting information (Task 2), and information important to assessing public perception and providing effective public outreach (Task 3). **Subtask 5.3 – Scenario Screening –** will develop and implement a screening matrix to ensure realistic alternatives and set practical limits on the number and types of project scenarios for RCSP Phase II as well as later R&D applications. **Subtask 5.4 – Scenario Modeling –** will develop and utilize a computer-based methodology, using commercial spreadsheet software, to assess and rank scenarios for Phase II RCSP projects as well as well as long-term R&D applications. **Subtask 5. 5 – Action Plan Development –** will prepare detailed action plans for sequestration implementation and technology validation activities to be performed in Phase II to include plans for public involvement, regulatory and permitting requirements and performance matrices and cost accounting.

4.4 Deliverables

See Figure 4.1 for a list of deliverables and milestones.

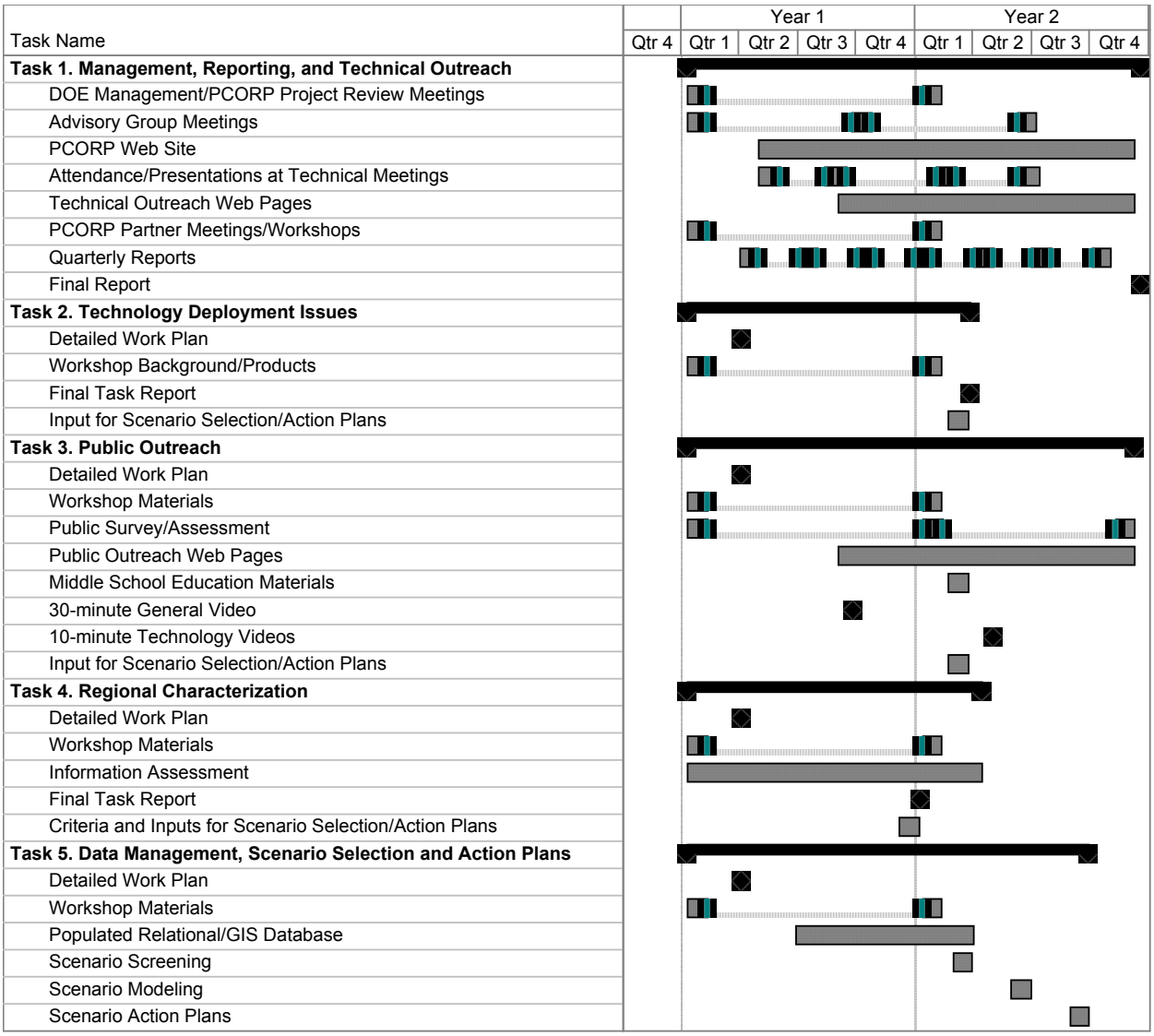

Figure 4.1. Milestones and deliverables for tasks and subtasks.

4.5 Description of Proposed Travel

Proposed travel includes trips both inside and outside the PCORP region as well as detailed briefings and Annual Contractor Review Meetings as specified in the solicitation. Trips are estimated for one or two people for a duration of 3 days. Year 1 includes 15 trips within the PCORP region (three per active task) for the purpose of stakeholder/industry meetings as well as project partner collaborations and information sharing. Five trips outside the PCORP region (one per active task) in Year 1 are for the purposes of attending conferences, giving presentations, and

interacting with other regional CO_2 sequestration centers. Year 2 includes 12 trips within the PCORP region (three per active task) and four outside the region (one per active task) for purposes similar to those in Year 1. One NETL briefing and a Contractor Review Meeting are scheduled in both project years.

4.6 Description of Potential Obstacles and Mitigation Mechanisms

The overall strategy for the mitigation of potential obstacles is based on the diversity and strengths of the project team. The partners involved bring all of the skill sets needed for the successful completion of the project. The superb level of participation by the commercial fossil fuel-fired power facilities in the PCORP region ensures that realistic and comprehensive datasets will be collected to characterize the region, relevant criteria for technology selection will be used, the technologies selected for technology demonstrations will have the most commercial potential for deployment, and the action plans for implementation and technology validation activities will be realistic and have a high probability of success. Table 4.3 lists the potential obstacles for project success and the mechanisms proposed for mitigation of the potential problems on a task-by-task basis.

Table 4.3. Potential Obstacles for Project Success

Task	Potential Obstacle	Mitigation Strategy
1	Project schedule delayed	Effective and experienced team leaders — EERC management and experience with multidisciplinary organizationally complex projects
	Project reporting delayed or insufficient quality	See above
2	Regulatory issues	– Involvement and support of regional regulatory agencies – Experience with regulatory issues from commercial partners
	Safety issues	– Health and safety; experience of commercial partners
	Permitting issues	Permitting experience of commercial partners
	Public perception issues	Task 3 results incorporated into technology selection from project inception and throughout project
	Ecosystem effects	Development of effective criteria to measure ecosystem effects
	Monitoring and verification	Development of comprehensive and effective monitoring and verification plan through involvement of regulatory, industrial, and research partners
3	Negative public perceptions delay or negate otherwise viable technology	Task 3 is designed to inform public from project inception and provide continuous feedback as technologies are considered
4	Ineffective source characterization	– Experienced, diverse project team – Familiarity with region
	Ineffective sink characterization	See above
	Ineffective infrastructure characterization	See above
5	Database structure that overwhelms or impedes decision support model	Experienced project GIS database team
	Ineffective decision support model	Experienced and diverse project team

5.0 REFERENCES

1. National Energy Technology Laboratory. Carbon Sequestration Technology Roadmap and Program Plan. http://netl.doe.gov/coalpower/sequestration (accessed March 12, 2003).
2. U.S. Environmental Protection Agency. State Energy CO_2 Inventories. http://yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsIndividual.html.
3. Renewable Fuels Association. U.S. Fuel Ethanol Production Capacity. http://ethanolrfa.org/eth_prod_fac.html.
4. Thomas, D. (Advanced Resources International). Climate Change: A Challenging Opportunity for Industry and Government: Presentation to the Interstate Oil and Gas Compact Commission (IGCC), Alta, UT, July 17–19, 2002. http://www.iogcc.state.ok.us/ISSUES/CO2%20Sequestration/co2sequestion.html.
5. Hattenbach, R.P.; Wilson, M.; Brown, K.R. Capture of Carbon Dioxide from Coal Combustion and Its Utilization for Enhanced Oil Recovery. *Applied Energy* **1995**, *62*, 217–221.
6. Gulf Exploration and Production Company. *Little Knife Field CO_2 Minitest*, *Billings County, North Dakota*; Final Report for U.S. Department of Energy Contract No. DE-AC21-79MC08383; DOE/MC/08383-45; June 1983.
7. Science Applications Inc. *Feasibility and Economics of By-Product CO_2 Supply for Enhanced Oil Recovery*: Final Report for U.S. Department of Energy Contract No. DE-AT21-78MC08333; Task 36, DE82004815; Jan 1982.
8. Stricker, G.D.; Flores, R.M. Potential Carbon Dioxide Sequestration and Enhanced Coalbed Methane Production in the Powder River and Williston Basins. In *Proceedings of the 28th International Technical Conference on Coal Utilization & Fuel Systems*; Clearwater, FL, March 9–13, 2003. www.coaltechnologies.com.; 15 p.
9. U.S. Department of Energy Energy Information Administration. DOE/EIA-0095(2000)/1, 339, March 2002.
10. Gunter, W.D.; Wong, S.; Cheel, D.B.; Sjostrom, G. Large CO_2 Sinks: Their Role in the Mitigation of Greenhouse Gases from an International, National (Canadian), and Provincial (Alberta) Perspective. *Appl. Energy* **1998**, *61*, 209–227.
11. Timpe, R.C.; Aulich, T.R. *Economic Source Sited Long-Term CO_2 Sequestration*; Draft Final Report for Task 7.2, Activity 2, U.S. Department of Energy Cooperative Agreement No. DE-FC26-98FT40320; June 2002, 13 p.
12. United States Geological Survey/National Energy Technology Laboratory. MIDCARB Web Site. www.kgs.ukans.edu/Midcarb.

APPENDIX B

LETTERS OF COMMITMENT AND SUPPORT

MONTANA-DAKOTA
UTILITIES CO.
A Division of MDU Resources Group, Inc.

400 North Fourth Street
Bismarck, ND 58501
(701) 222-7900

March 10, 2003

Mr. Thomas A. Erickson
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear Tom:

Montana-Dakota Utilities Co. is pleased to write this letter committing $30,000 over two years in support of the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership." Montana-Dakota Utilities Co generates, transmits and distributes electricity and provides related value-added products and services in the Northern Great Plains.

We look forward to a very successful project and are confident that the EERC's long-standing expertise and partnership building will result in a very successful regional CO_2 sequestration center.

Sincerely,

Bruce Imsdahl

Bruce Imsdahl
Executive Vice President

215 South Cascade Street
PO Box 496
Fergus Falls, Minnesota 56538-0496
218 739-8200
www.otpco.com (web site)

OTTER TAIL POWER COMPANY

March 21, 2003

Mr. Thomas A. Erickson
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear Tom;

Otter Tail Power Company is pleased to write this letter committing $30,000 over two years in support of the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership." Otter Tail Power Company generates, transmits and distributes electricity and provides related value-added products and services in the Northern Great Plains Region.

Otter Tail Power Company has always strived to protect the environment, even prior to the onset of many environmental requirements and laws. We have also supported research and development activities leading to the commercialization of new environmental control systems such as the EERC's Advanced Hybrid unit. The EERC has continually demonstrated their expertise to address a broad range of energy and environmental topics that will shape the future of the power generation market.

We look forward to a very successful project and are confident that the EERC's long-standing expertise and partnership building will result in an exceptional regional CO_2 sequestration center.

Sincerely,

Terry Graumann
Manager, Environmental Services

BASIN ELECTRIC POWER COOPERATIVE

1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA 58503-0564
PHONE 701-223-0441
FAX: 701/224-5336

March 19, 2003

Mr. Thomas A. Erickson
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58502

Dear Mr. Erickson:

Basin Electric Power Cooperative is pleased to write this letter in support of the Energy and Environmental Research Center's proposal entitled "The Northern Great Plains CO2 Reduction Partnership." Basin Electric will commit $15,000 per year for two years ($30,000 total) to support this project. As a coal-based utility generator, Basin Electric has followed with considerable interest the developments relative to carbon sequestration. This partnership by EERC will help bring increased understanding of the opportunities for carbon sequestration options related to both geologic and terrestrial applications.

We are confident that the EERC's long-standing expertise in the development, testing, and validation of innovative energy production, conversion and processing technologies coupled with the considerable technical, business, and financial resources of the other members of PCORP will result in a very successful regional CO2 sequestration center. Basin Electric's subsidiary, Dakota Gasification Company, is an innovative partner in a leading international project to utilize CO2 for enhanced oil production and carbon sequestration. The expertise and strength of EERC coupled with the knowledge gained in this international project will result in a strong partnership delivering significant value to the Department of Energy.

Basin Electric is a consumer-owned, regional cooperative headquartered in Bismarck, North Dakota. Basin Electric generates and transmits electricity to 124 member rural electric systems in nine states: Colorado, Iowa, Minnesota, Montana, Nebraska, New Mexico, North Dakota, South Dakota, and Wyoming. These members distribute electricity to approximately 1.7 million consumers. The growing political debate relative to carbon sequestration is important to Basin Electric and our member-owners in planning for a reliable, affordable energy future.

We look forward to participating in a very successful regional project.

Sincerely,

Ronald R. Harper
CEO and General Manager

rrh/gae

INDUSTRIAL COMMISSION OF NORTH DAKOTA

LIGNITE RESEARCH, DEVELOPMENT AND MARKETING PROGRAM

Governor,
John Hoeven
Attorney General,
Wayne Stenehjem
Agriculture Commissioner,
Roger Johnson

March 24, 2003

Mr. Thomas Erickson
Associate Director for Research
Energy & Environmental Research Center
P. O. Box 9018
Grand Forks, ND

Subject: Proposal entitled "Development of a Regional Carbon Sequestration Center"

Dear Tom:

This letter is in response to your request for participation in the proposed Energy & Environmental Research Center project entitled "Development of a Regional Carbon Sequestration Center" submitted to the U. S. Department of Energy, Solicitation DE-PS26-03NT41713, "Regional Carbon Sequestration Partnerships - Phase I."

The North Dakota Lignite Research, Development and Marketing Program (Program) is committed to the development and commercialization of advanced technologies for the power generation industry. As Federal regulations continue to become more stringent, it is important to identify regional resources and options to address anticipated environmental issues such as carbon sequestration.

This letter of support and potential funding of up to $240,000 from the North Dakota Program is subject to submission of a proposal by the Energy & Environmental Research Center at the University of North Dakota. North Dakota funding is also subject to submission of a proposal that meets Program guidelines, a funding recommendation by the Lignite Research Council and approval by the North Dakota Industrial Commission.

Environmental issues and growth of our lignite industry are priorities for the North Dakota Program. Funding guidelines require matching industrial funds and activities that preserve and enhance the use of North Dakota lignite.

Sincerely,

Harvey M. Ness
Director and Technical Advisor,
Lignite Research, Development and Marketing Program

cc: Karlene Fine, Executive Director and Secretary, North Dakota Industrial Commission
John W. Dwyer, Chairman, Lignite Research Council

LIGNITE RESEARCH COUNCIL

John Dwyer
Chairman
jdwyer@lignite.com

Harvey Ness
Director & Technical Advisor
lness@lignite.com

P.O. Box 2277
Bismarck, N.D. 58502

(701) 258-7117 (701) 258-2755 FAX

INDUSTRIAL COMMISSION OF NORTH DAKOTA

Karlene Fine
Executive Director & Secretary
kfine@state.nd.us
600 E. Blvd., State Capitol
Bismarck, N.D. 58505

(701) 328-3722 (701) 328-2820 FAX

INTERSTATE OIL AND GAS COMPACT COMMISSION

P.O. Box 53127, Oklahoma City, OK 73152-3127
Phone: 405/525-3556 • Fax: 405/525-3592 • E-mail: iogcc@iogcc.state.ok.us
World Wide Web http://www.iogcc.state.ok.us

Chairman: Governor John Hoeven, North Dakota
Vice Chairman: Russell J. Harding, Michigan
Second Vice Chairman: Lynn D. Helms, North Dakota
Executive Director: Christine Hansen

March 21, 2003

Mr. John A. Harju
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
P.O. Box 9018
Grand Forks, ND 58202

Dear John,

The Interstate Oil & Gas Compact Commission (IOGCC) is pleased to present this letter of support for the Energy & Environmental Research Center's (EERC) proposed project entitled "The Northern Great Plains CO2 Reduction Partnership (PCORP)." The IOGCC is committed to supporting the President's Global Climate Change Initiative and to supporting research regarding the storage, transport, utilization and sequestration of CO2 through the development of a regional center.

I believe that the technical, business and financial resources represented by EERC and other members of PCORP will result in a successful regional CO2 sequestration center.

The IOGCC will be happy to act in an advisory capacity to your efforts, providing information on oil and gas industry activities in the key oil and gas producing states in your region (North Dakota, South Dakota, Montana, and Wyoming), and especially regulatory issues as they may relate to the utilization or sequestration of CO2. The IOGCC will use its experience, expertise and contacts to provide EERC with states' perspectives on the respective roles that regulatory agencies and the oil and gas industry can play regarding these issues.

I look forward to working with you on this effort.

Sincerely,

Christine Hansen
Executive Director

PTTC
TECHNOLOGY CONNECTIONS

March 7, 2003

Mr. John A. Harju
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear John;

The Petroleum Technology Transfer Council (PTTC) is pleased to write this letter of support regarding the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership." The PTTC shares the EERC's commitment to support research regarding the capture, storage, transport, and sequestration of CO2 through the development of a regional center for the reduction and sequestration of CO_2. We are confident that the EERC's long-standing expertise in the development, testing, and validation of innovative energy production, conversion and processing technologies coupled with the considerable technical, business, and financial resources of the other members of PCORP will result in a very successful regional CO_2 sequestration center.

The PTTC will be happy to facilitate technology transfer activities as a portion of your efforts, in particular those related to Enhanced Oil Recovery and to enhanced Coalbed Methane production, should your project be successfully funded. This would be above the activities that we currently undertake to satisfy our national contractual obligations. As you know, North Dakota, Wyoming, Montana, and South Dakota are all parts of both your Northern Great Plains and our Rocky Mountain Region. Our Rocky Mountain Region's activities are coordinated out of the Colorado School of Mines. I encourage you to speak further with both myself and Dr. Sandra Mark at the Colorado School of Mines as your activities and needs become better defined.

Sincerely,

Don Duttlinger
Executive director

PETROLEUM TECHNOLOGY TRANSFER COUNCIL

16010 Barkers Point Lane, Suite 220, Houston, TX 77079 ■ www.pttc.org
281-921-1720 ■ Toll Free 1-888-THE-PTTC ■ Fax 281-921-1723 ■ hq@pttc.org

FISCHER OIL and GAS, INC.
5749 83rd Street South
Grand Forks, North Dakota 58201-9120

March 20, 2003

Mr. John A. Harju
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear John;

Fischer Oil and Gas, Inc. is pleased to write this letter of support regarding the proposed project entitled "The Northern Great Plains CO2 Reduction Partnership." Fischer Oil and Gas, Inc. shares the EERC'S commitment to support research regarding the capture, storage, transport, value-added use, and sequestration of CO2 through the development of a regional center for the reduction and sequestration of CO2. We are confident that the EERC'S long-standing expertise in the development, testing, and validation of innovative energy production, conversion and processing technologies coupled with the considerable technical, business, and financial resources of the other members of PCORP will result in a very successful regional CO2 sequestration center.

Fischer oil and Gas, Inc. & Gas will be happy to help the project team evaluate the potential for geologic sequestration and opportunities for uses of CO2 in Enhanced Oil Recovery activities. We are also interested in the potential for uses of CO2 in enhanced coalbed methane production, and in helping guide PCORP's assessments in these regards.

Sincerely,

David Fischer
President
Fischer Oil and Gas, Inc.

701-746-8509 phone 701-746-0870 fax
fischerd@infi.net

Minnesota Pollution Control Agency

March 19, 2003

Mr. Thomas A. Erickson
Energy & Environmental Research Center
15 North 23rd Street
P.O. box 9018
Grand Forks, ND 58202-9018

Mr. Erickson:

The Minnesota Pollution Control Agency is willing to collaborate with the Energy & Environmental Research Center in the development of strategies for carbon sequestration. We recognize the need to develop any future strategies with a strong focus on environmental and regulatory concerns. Our involvement will include review of potential sequestration ideas relevant to Minnesota and discussions of related issues. Our involvement will be limited to our availability at any given time.

Sincerely,

J. David Thornton
Section Manager
Policy Planning & Operations Support Section
Majors and Remediation Division

JDT:jae

520 Lafayette Rd. N.; St. Paul, MN 55155-4194; (651) 296-6300 (Voice); (651) 282-5332 (TTY)
St. Paul • Brainerd • Detroit Lakes • Duluth • Mankato • Marshall • Rochester • Willmar; www.pca.state.mn.us

GREAT RIVER
ENERGY®

17845 East Highway 10 • P.O. Box 800 • Elk River, Minnesota 55330-0800 • 763-441-3121 • Fax 763-241-2366 • www.GreatRiverEnergy.com

SENT VIA E-MAIL AND
US POSTAL SERVICE

March 27, 2003

Mr. Thomas A. Erickson
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear Tom:

Great River Energy is pleased to write this letter committing $30,000 over two years in support of the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership (PCORP)". Great River Energy is Minnesota's second largest electric utility based on generating capacity, and provides electrical energy and services to 28 distribution cooperatives in Minnesota and Wisconsin.

Great River Energy has a long history of working with the EERC. We are confident that the EERC's long-standing expertise in the development, testing, and validation of innovative energy production, conversion and processing technologies coupled with the considerable technical, business, and financial resources of the other members of PCORP will result in a very successful regional CO_2 sequestration center. We look forward to a very successful project.

Sincerely,

GREAT RIVER ENERGY

Mark Strohfus
by D. Nix

Mark Strohfus
Environmental Policy Analyst

MS/bn

S:\CorpServ\EnviServ\EERC NoGrPlns CO2 Reduc Ptnrshp
\GRE 30k Commitment 3-27-03.doc

NDSU NORTH DAKOTA STATE UNIVERSITY

Department of Agribusiness and Applied Economics
P.O. Box 5636
Fargo, ND 58105-5636

701.231.7441
Fax 701.231.7400
coa-econ@ndsuext.nodak.edu

March 17, 2003

Thomas A. Erickson
Associate Director for Research
Energy & Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202-9018

Dear Tom:

This letter constitutes our proposal to contribute to the Regional Sequestration Center through analysis of the potential of agricultural soil carbon sequestration to regional/national goals. As outlined in our attached discussion of **Problem/Objectives/Methods**, we will be evaluating the effect of alternative agricultural land management practices on (1) levels of soil carbon sequestration and (2) farm and ranch profitability. An economic model to be developed by researchers in the NDSU Dept. of Agribusiness & Applied Economics (NDSU AAE) will provide estimates of the levels of incentive payments needed to encourage adaption of production practices that lead to increased soil carbon sequestration. Specific objectives will include: (1) analysis of data from a series of test plots (initiated in 1999) at the Hettinger Research Extension Center (HREC), (2) soil carbon testing from sites across the region to determine how rapidly soil organic matter/soil carbon levels increase when previously cropped land is returned to perennial grass cover, across a variety of soil types, and (3) developing a farm economic simulation model to evaluate farmer/rancher changes in land management practices in response to incentives.

Personnel:

Key personnel for the NDSU effort will include F. Larry Leistritz, Timothy Faller, and Larry Cihacek. Dr. Leistritz will be principal investigator for the project. Director Faller will be co-PI and will be responsible for research on the experimental plots at the HREC. Dr. Cihacek will be responsible to the soil carbon analyses, both for samples collected from the HREC plots and from the regional soil survey. Resumes for Leistritz and Faller are attached.

Budget:

The total cost for accomplishing these objectives will be $174,753, of which $139,803 is requested from the Center/DOE (consisting of $99,151 of direct costs and $40,652 indirect costs, see budget breakdown below). In-kind cost share will be provided in the amount of $34,950 (20% of total costs). The cost share will consist of salaries and fringe benefits for Leistritz, Faller, and Cihacek ($24,788) plus indirect costs forgone ($10,162).

Unit	Budget by Year Year 1	Year 2	Total
HREC	$18,761	$18,750	$37,511
NDSU Soils	22,000	18,000	40,000
NDSU AAE	18,000	3,640	21,640
Total Direct Costs	58761	40,390	99,151
Indirect cost (41%)	24,092	16,560	40,652
Total Cost	$82,853	$56,950	$139,803

A detailed budget breakdown and cost justification is attached. The budget includes funds to travel to the EERC for four project meetings and to travel to a DOE review meeting in Morgantown, WV.

NEPA Compliance:

A NEPA questionnaire for the HREC plots is enclosed.

Capabilities/Facilities:

A brief description of the North Dakota Agricultural Experiment Station and the facilities and equipment available to support the proposed project is attached.

I hope this letter and enclosures provides the information you need. Should any questions arise, please don't hesitate to contact me (701-231-7455) or Tim Faller (701-567-4324).

Sincerely,

F. Larry Leistritz
Professor

Valrey Kettner, Vice President for
Sponsored Programs Administration,
North Dakota State University

Cc. T. Faller
L. Cihacek

DAKOTA GASIFICATION COMPANY
A BASIN ELECTRIC SUBSIDIARY

MAILING ADDRESS:
P.O. BOX 5540
BISMARCK, NORTH DAKOTA 58506-5540
PHONE: 701/221-4400 FAX: 701/221-4450

STREET ADDRESS:
SUITE ONE
1600 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA 58503-0561

Great Plains SYNFUELS

March 12, 2003

Thomas A. Erickson
Associate Director for Research
Energy & Environmental Center
PO Box 9018
Grand Forks, ND 58202-9018

Dear Mr. Erickson:

On behalf of the Dakota Gasification Company, I write to inform you of our desire to become a research partner in the regional sequestration project that the Energy & Environmental Center (EERC) is applying through the Department of Energy.

As you know, the Dakota Gasification is the only commercial-scale coal gasification plant in the United States. The Department of Energy was instrumental in building of the plant by guaranteed loans and assuming actual operations of the plant for three years. The Department has consistently been supportive of the plant in its effort to enhance environmental technology and performance.

Our company has been involved in the largest industrial carbon sequestration projects in the nation. Currently, over 70 million cubic feet of carbon dioxide per day is sent by pipeline to Canada and injected into deep geologic formation thousands of feet below the earth's surface to recover 25, 000 barrels of oil daily.

For these reasons, I feel that the Dakota Gasification Company would be an excellent research partner with the EERC in a regional sequestration project. Our company has first-hand experience in carbon sequestration for enhanced oil recovery, but much more can be done.

Attached is a budget and work scope for $10,000 for activities that Dakota Gasification will perform for this project. Additionally, Dakota Gasification is able to provide up to $700,000 of in-kind support through the release of critical information and reports that are not publicly available for use in this program.

I look forward to working with the EERC in this regional sequestration project.

Sincerely,

Alan C. Lukes
Senior Vice President

acl
Enclosures

Nexant

March 19, 2003

Thomas A. Erickson
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
Box 8213, University Station
Grand Forks, ND 58202

Dear Dr. Erickson:

Subject: U.S. DOE Solicitation DE-PS26-03NT41713, Regional Carbon Sequestration Partnerships – Phase I

Nexant, Inc., a Bechtel affiliated company is pleased to offer support and engineering services for the subject Department of Energy project. We are well aware of efforts by the Energy & Environmental Research Center (EERC) to lead this important work in the West and Midwest United States. Nexant's work with many DOE NETL projects (We are presently the engineer for WMPI and the DOE's Early Entry Co-Production Plant, which will be demonstrated in the just awarded Clean Coal and Power Initiative.), the Zero Emission Coal Alliance, the Carbon Capture Project, and others has convinced our management and technical specialists that while debates about the causes and impacts of global climate change continue in technical and political arenas, there is no question that CO_2 emissions by industry, transportation and other operations of a growing world population are raising the amount of CO_2 in the atmosphere. While tremendous progress has been made by industry and government to improve the efficiency of electric power generation, transportation systems and other high energy consuming industries (and thus, potential large CO_2 emitters), it is prudent for government and industry to assess new options for limiting greenhouse gases via geological and terrestrial sequestration.

Nexant proposes to work with the Regional Team and perform engineering, cost/economic evaluations, database assistance and consulting. A brief scope of work, budget and other proposal material are attached. We estimate that our scope of work can be performed for a total of $105,600, split about 40% in the 12 months and 60% in the second 12. We hope that our experience with global climate change issues, and our work with carbon source industries, government technology and regulatory organizations, and the companies providing equipment and other components for systems to separate, capture, transport and safely sequester CO_2 will prove valuable to the EERC team.

We propose to assist the team in the assessment of existing and future carbon sources; the evaluation and comparison of commercial and advanced separation and capture technologies; life cycle assessments, and with the technical – economic aspects of gas treatment, compression and transportation. We also offer to assist with the database building and software development to evaluate the multiple options in the region. Finally, Nexant offers our skills to help Phase I planning, and then the engineering and installation of tests and pilot plant operations that will follow Phase I.

We look forward to working with the EERC team on this project that we believe is crucial not just for the Region, but to North America and the World. If there are any questions or if we can be of any assistance, please contact me at 415 369-1077 or John Ruby at 415 369-1063.

Sincerely,

Tan-Ping Chen

T. P. Chen
Vice President, Nexant

Nexant, Inc.
101 Second Street
San Francisco, CA 94104-3672
USA

26 March 2003

Dear Mr. Erickson,

This letter is to inform you that Prairie Public Television is committed to playing a key role in helping the public to understand the issues and opportunities related to CO2 sequestration in the northern Great Plains as part of the Energy & Environmental Research Center's (EERC's) "Plains CO2 Reduction Partnership" (PCORP). Further, as part of this activity, Prairie Public Television will provide both technical (as a subcontractor) and in-kind matching support.

Prairie Public Television currently serves the 520,000 households of the PCORP region including the 360,000 households in Minnesota, North and South Dakota, and eastern Wyoming and Montana, as well as 170,000 households in the Canadian Provinces of Saskatchewan and Manitoba. Over the past several years, Prairie Public Television has met the challenge of informing our diverse international audience regarding a variety of complex regional issues that involve government, business, technology, science, and the environmental community. For example, Prairie Public is currently involved in multi-faceted flood-information effort that includes programming, web site development, and educational materials that provides information on policy, risk assessment, infrastructure, and forecasting, as well as real-time event information, to over 300,000 Red River Valley households in the US and in Canada. In a similar fashion, Prairie Public has worked with the EERC and other local stakeholders and experts to develop videos and other educational materials to raise the awareness of the public in the Fargo, North Dakota, metropolitan area with respect to water resource issues.

Under PCORP, Prairie Public will build on this experience to develop a half hour program informing the public with respect to the CO2 sequestration issues, DOE's national Regional Carbon Sequestration Partnership program and the regional Plains CO2 Reduction Partnership (PCORP), and major sequestration methods and opportunities in the region. Following the production of this program in Year 1, in Year 2 Prairie Public will develop videos profiling three regional sequestration opportunities chosen by PCORP. These materials will be aired throughout our viewing area and will also be made available for use in schools through collaborative efforts with Prairie School Television which is available to every K-12 classroom in North Dakota. Programs will also be made available to public television stations throughout the region as well as for use at informational forums and public events. In preparation for these documentary projects, and to report on progress and gather data, Prairie Public will participate in appropriate meetings throughout the state and will travel to Beulah, ND to gather materials regarding

Dakota Gasification. Prairie Public requests $75,000 to provide these services with $50,000 allocated to year one and $25,000 allocated to year two. In addition to these requested amounts, Prairie Public pledges $45,100 Year 1 and $21,475 Year 2 in in-kind to support this activity.

In closing, Prairie Public welcomes the opportunity to take part in this regional partnership that supports the mission and long range goals of the U.S. Department of Energy's Global Climate Change Initiative as well as the Carbon Sequestration Technology Roadmap and Program Plan.

Sincerely,

Robert O. Dambach
Director of Television

AMERADA HESS CORPORATION

113 EAST FOURTH ST
WILLISTON, NORTH DAKOTA 58801-5438
701-774-9000

March 26, 2003

Mr. John A. Harju
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear John;

I am pleased to write this letter of support regarding the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership." Amerada Hess Corporation sees the need and shares EERC's commitment to developing realistic strategies for the capture, storage, transport, value-added use, and sequestration of CO_2 through the establishment of a regional center for the reduction and sequestration of CO_2. We are confident that the EERC's expertise in the development, testing, and validation of innovative energy production, conversion and processing technologies coupled with the considerable technical, business, and financial resources of the other members of the project team will result in a very successful regional CO_2 sequestration center.

We will be happy to provide the project team with advice and insight regarding technical and economic factors that might affect the use of CO_2 for enhanced oil recovery activities, guidance on the potential for sequestration of CO_2 in depleted oil and gas reservoirs in the Williston Basin, and on the potential utilization of CO_2 for enhanced coalbed methane production.

Sincerely,

Wayne Biberdorf
Operations Manager

North Dakota Geological Survey

INDUSTRIAL COMMISSION
John Hoeven - Governor, Chairman
Wayne Stenehjem - Attorney General
Roger Johnson - Commissioner of Agriculture

John P. Bluemle, State Geologist

March 26, 2003

Mr. John A. Harju
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear John:

The North Dakota Geological Survey is pleased to present this letter of support for the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership." The NDGS is committed to supporting research regarding the storage, utilization, and sequestration of CO_2 through the development of a regional center for the reduction and sequestration of CO_2. We believe that the technical, business, and financial resources represented by the EERC and the other members of PCORP will result in a successful regional CO_2 sequestration center.

The NDGS will act in an advisory capacity to aid your efforts, providing readily available information on the geology of North Dakota as it may relate to the utilization or sequestration of CO_2. We will make our data, knowledge, and experience available to provide EERC with guidance and advice regarding the use of geologic sinks for the efficient and economical sequestration of CO_2 in North Dakota.

Sincerely,

John P. Bluemle
State Geologist

600 East Boulevard Avenue ❖ Bismarck, North Dakota 58505-0840 ❖ Phone (701) 328-8000 ❖ Fax (701) 328-8010

WESTERN
GOVERNORS'
ASSOCIATION

Judy Martz
Governor of Montana
Chair

Bill Richardson
Governor of New Mexico
Vice Chairman

James M. Souby
Executive Director

Headquarters:
1515 Cleveland Place
Suite 200
Denver, Colorado 80202-5114

303-623-9378
Fax 303-534-7309

Washington, D.C. Office:
400 N. Capitol Street, N.W.
Suite 388
Washington, D.C. 20001

202-624-5402
Fax 202-624-7707

www.westgov.org

March 28, 2003

Carl Michael Smith
Assistant Secretary
Office of Fossil Energy
U.S. Dept of Energy
Room 4G-084
1000 Independence Ave., S.W.
Washington, DC 20585

Dear Mr. Smith:

As you know, the Western Governors' Association (WGA) will be coordinating certain technical and public outreach activities for regional carbon sequestration partnerships (RCSP) in the West funded as a result of the Department's solicitation of December 16, 2002. Because of the tremendous energy potential from carbon based fuels, and from the potential enhanced recovery of these fuels, the development of carbon sequestration opportunities are of extraordinary importance to our region. We therefore encourage you to provide support to as many Western proposals as possible.

Through our individual offices we have identified and been contacted by a number of the Western RCSP proposal teams. From representatives of these teams we have learned what WGA umbrella roles would be of most value to them and we have explained to them the importance of coordinating public outreach by the successful RCSPs.

The Plains CO_2 Reduction Partnership, among others, has agreed to work with WGA on shared technical and public outreach issues as the projects go forward. We are, therefore, pleased to endorse their proposal from a regional coordination perspective and hope you will give them strong consideration.

Thank you for your consideration of these proposals. We look forward to working with the successful Western RCSPs and your office.

Sincerely,

Judy Martz
Governor of Montana
Chair

Bill Richardson
Governor of New Mexico
Vice Chair and Lead Governor for Energy

cc: Plains CO_2 Reduction Partnership

NORTH DAKOTA INDUSTRIAL COMMISSION

OIL AND GAS DIVISION

Lynn D. Helms
DIRECTOR

http://explorer.ndic.state.nd.us

Bruce E. Hicks
ASSISTANT DIRECTOR

March 26, 2003

Mr. John A. Harju
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear John;

The Oil & Gas Division of the North Dakota Industrial Commission is pleased to present this letter of support for the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership." The NDIC-OGD is committed to supporting research regarding the storage, utilization, and sequestration of CO_2 through the development of a regional center for the reduction and sequestration of CO_2. I believe that the technical, business, and financial resources represented by the EERC and the other members of PCORP will result in a very successful regional CO_2 sequestration center.

The NDIC-OGD will be happy to act in an advisory capacity to your efforts, providing readily available information on oil and gas industry activities in North Dakota as they may relate to the utilization or sequestration of CO_2. The NDIC-OGD will use its experience and expertise to provide EERC with the State's perspective on the role that the oil and gas industry can play in the utilization and sequestration of CO_2 in North Dakota.

Sincerely,

Lynn D Helms

Lynn Helms
Director
North Dakota Oil & Gas Division

600 E Boulevard Ave Dept 405, Bismarck, North Dakota 58505-0840 Phone(701)328-8020 Fax(701)328-8022

Montana Department of
ENVIRONMENTAL QUALITY
Judy H. Martz, Governor

P.O. Box 200901 • Helena, MT 59620-0901 • (406) 444-2544 • Website: www.deq.state.mt.us

March 26, 2003

Thomas A. Erickson
Energy & Environmental Research Center
15 N 23rd Street
P.O. Box 9018
Grand Forks, ND 58202 - 9018

Dear Mr. Erickson:

The Department of Environmental Quality (DEQ) conducted the inventory of greenhouse gas emissions in Montana and continues to monitor developments in climate change science and policy. We are open to working with any group on the development of strategies for carbon sequestration. Accordingly, we would be pleased to work with the Energy & Environmental Research Center if it begins a program of testing and eventually demonstrating CO_2 sequestration technologies in the northern Great Plains. We recognize the need for any future strategies to focus on environmental and regulatory concerns. Our involvement will include review of potential sequestration ideas relevant to Montana and discussions of related issues. Our involvement will be limited to our availability at any given time.

Sincerely,

Art Compton, Administrator
Planning, Prevention and Assistance Division

NORTH DAKOTA DEPARTMENT OF HEALTH
Environmental Health Section

Location:
1200 Missouri Avenue
Bismarck, ND 58504-5264

Fax #:
701-328-5200

Mailing Address:
P.O. Box 5520
Bismarck, ND 58506-5520

March 31, 2003

Mr. John A. Harju
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
P.O. Box 9018
Grand Forks, ND 58202

Dear Mr. Harju:

The North Dakota Department of Health is pleased to present this letter of support for the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership." The Department encourages research regarding the storage, utilization, and sequestration of CO_2 through the development of a regional center for the reduction and sequestration of CO_2. It is expected that the technical, business, and financial resources represented by the EERC and the other members of PCORP will result in a successful regional CO_2 sequestration center.

The Department's Air Quality Division is willing to act in an advisory capacity to such efforts, providing guidance and advice with regard to permitting issues in North Dakota as they may relate to the utilization or sequestration of CO_2. The Air Quality Division is willing to offer its experience and expertise to provide EERC with the State's perspective on the environmental regulatory aspects of CO_2 utilization and sequestration in North Dakota.

Sincerely,

Terry O'Clair

Terry L. O'Clair, P.E.
Director
Division of Air Quality

TLO:saj

Environment Canada | Environnement Canada

Ottawa Ontario
K1A 0H3

March 18, 2003

Mr. John A. Harju
Associate Director for Research
Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202

Dear John,

Environment Canada is pleased to write this letter of support regarding the EERC's proposed project entitled "The Northern Great Plains CO_2 Reduction Partnership." Environment Canada shares the EERC's commitment to support research regarding the capture, transport and storage of CO_2 through the development of a regional center for the reduction and sequestration of CO_2. I am confident that the technical, business, and financial resources represented by the EERC and the other members of the Partnership will result in a very successful regional CO_2 sequestration center.

Environment Canada will be happy to act in an advisory capacity to your efforts, identifying individuals and organizations with expertise in the areas you wish to pursue, in particular those related to the CO_2 enhanced oil recovery project in Weyburn, Saskatchewan and to enhanced coalbed methane production. CO_2 sequestration is an international issue and I'm pleased that EERC has seen fit to include Manitoba and Saskatchewan in its study region. The CO_2 EOR project at Weyburn, which uses CO_2 produced at the Dakota Gasification Plant in North Dakota, is an excellent example of how Canadian and American cooperation can lead to successful utilization of CO_2 in the Northern Great Plains. Environment Canada will use the knowledge and experience gained from its participation in the Canadian CO_2 Capture & Storage Technology Network to provide EERC with advice on developing a roadmap for efficient and economical sequestration of CO_2 in North America.

Sincerely,

W. A. Reynen

Bill Reynen
Head, Upstream Oil and Gas Section
Oil, Gas and Energy Branch
Air Pollution Prevention Directorate
Environmental Protection Service
Environment Canada

Canada

APPENDIX C

RESUMES OF KEY PERSONNEL

DANIEL J. DALY
Geologist/Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax (701) 777-5181; E-Mail: ddaly@undeerc.org

Principal Areas of Expertise
Energy and environmental education, sustainable development, the evolution of energy and environmental policy, waste management for the energy industry and the nuclear defense complex, and the geology and hydrogeology of the northern Great Plains.

Qualifications
M.S., Geology, UND, 1984; B.A., Earth Science, New Mexico Highlands University, 1974.

Professional Experience
1985–Present: Research Manager/Geologist, EERC, UND.

- Fall 1999–Present: Management and program building as Coordinator of the Red River Valley Clean Cities Coalition (Clients: U.S. Department of Energy [DOE] and regional stakeholders); management for regional environmental education projects funded by U.S. Environmental Protection Agency and National Science Foundation.

- 1995–Present: Part 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 (Client: DOE).

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

- 1989–1998: Tracking and assessment of government policy and regulatory actions in support of strategic planning.

1975–1984: 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 on investigations of 1) environmental issues related to coal mining and coal conversion waste management and 2) geology and hydrology of the northern Great Plains Williston Basin region.

Relevant Publications
- Hartman, J.H., Crocker, C.R., and Daly, D.J., 2003, Red River Geoscience Education Pilot Project: Final report to the National Science Foundation for NSF Science Education Grant NSF00-38.

- Daly, D.J., and Crocker, C.R., 2001, North Dakota Red River Basin River Watch Project—laboratory field experience: Final report to the U.S. Environmental Protection Agency, Region 8, for U.S. EPA Environmental Education Grant Agreement No. NE 988221-01.

- Daly, D.J.; O'Leary, E.M.; Behr-Andres, C.B.; Steadman, E.N.; Groenewold, G.H. Environmental Technologies Acceptance (ETA) Program: NETL–Energy & Environmental Research Center. Poster Presented at the Industry Partnerships to Deploy Environmental Technology Conference, Morgantown, WV, Oct 30 – Nov 1, 2001.

- Erickson, T.A., Daly, D.J., and Steadman, E.N., 1998, Technology commercialization and deployment through dynamic partnerships: Presented at the Spectrum '98 Meeting, Denver, Colorado, September 13–18, 1998.

- Daly, D.J., Stoa, R.S., Bassingthwaite, S.A., Sorensen, J.A., and Charlton, D.S., 1995, Gas industry-related exploration and production waste "demographics" utilizing GIS, *in* SPE/EPA Exploration, and Production Environmental Conference, March 27–29, 1995, Houston, Texas, Proceedings.

- Daly, D.J., Stoa, R.S., Sorensen, J.A., and Bassingthwaite, S.A., 1995, Atlas of gas-related drilling waste for 1990: Gas Research Institute, Chicago, Illinois, Topical Report GRI-95/0017, 83 p.

- Energy & Environmental Research Center (Daly, D.J., Stoa, R.S., Sorensen, J.A., and Bassingthwaite, S.J.) and ENSR Consulting and Engineering (Mesing, G.E., Pemmaraju, S., Martz, K.D., and Tallon, J.T.), 1995, Atlas of gas-related produced water for 1990: Gas Research Institute, Chicago, Illinois, Topical Report GRI-95/0016, 88 p.

- Daly, D.J., and Schmit, C.R., Sholes, M.A., 1992, A review of the geology and depositional environments of the coal-bearing sequence in the Fort Union lignite region, *in* Finkelman, R.B., Tewalt, S.J., and Daly, D.J. (eds.), Geology and utilization of Fort Union lignites: Reston, Virginia, Environmental and Coal Associates, p. 3–51.

- Finkelman, R.B., Tewalt, S.J., and Daly, D.J. (eds.), 1992, Geology and utilization of Fort Union lignites: Reston, Virginia, Environmental and Coal Associates, 359 p.

THOMAS A. ERICKSON
Associate Director for Research
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax: (701) 777-5181; E-Mail: terickson@undeerc.org

Principal Areas of Expertise
Management of large multidisciplinary projects and development of environmental technologies, gasification and combustion processes, trace element transformations, process and product modeling, statistical design and evaluation, systems engineering, and scanning electron microscopy for coal and combustion product analysis.

Qualifications
M.S., Chemical Engineering, UND, 1990; B.S., Chemical Engineering, UND, 1988.

Professional Experience
1999–Present: Associate Director for Research, EERC, UND. Responsible for the direction of programs related to integrated energy and environmental system development. The research, development, and demonstration programs involve fuel quality effects on power system performance, advanced power systems development and demonstration, renewable energy systems and resources, computational modeling, advanced materials for power systems, and analytical methods for the characterization of materials. Responsible for the identification of research opportunities and the preparation of proposals and reports for clients.

1994–1999: Senior Research Manager, Engineering and Modeling Technologies, EERC, UND. Responsible for the management and operation of the Engineering and Modeling Technologies group, including personnel and budget planning, management of process and product modeling of combustion and gasification processes, and research related to toxic substance emissions during coal utilization.

1992–1994: Research Manager, Fuels and Materials Science, EERC, UND. Responsible for the organization and management of personnel and budgets, process and product modeling of combustion and gasification processes, and qualitative and quantitative analysis of coal and ash systems.

1991–1992: Supervisor, Analytical Research, EERC, UND. Responsible for the organization and management of personnel and budgets for an Inorganic Analytical Research Laboratory, quantitative and qualitative analysis of coal and its combustion products, and process modeling of transformations during combustion and gasification.

1990–1991: Research Engineer, Combustion Studies, EERC, UND. Responsible for the quantitative and qualitative analysis of coal and its combustion products to model and predict transformations during combustion.

1989–1990: Research Specialist II, Energy and Mineral Research Center, UND. Responsible for the operation and maintenance of a scanning electron microscope/ microprobe and supervision of student employees.

1988–1989: Research Specialist I, Energy and Mineral Research Center, UND. Responsible for the operation and maintenance of a vertically orientated, laminar-flow (drop-tube) furnace.

Relevant Publications

- Erickson, T.A.; Daly, D.J.; Groenewold, G.H.; Steadman, E.N. Environmental Management Technology Demonstration and Commercialization. Presented at the Industry Partnerships to Deploy Environmental Technology Conference, Morgantown, WV, Oct 12–14, 1999.

- Erickson, T.A.; Daly, D.J.; Steadman, E.N. Technology Commercialization and Deployment Through Dynamic Partnerships. Presented at the Spectrum '98 Meeting, Denver, CO, Sept 13–18, 1998.

- Jensen, R.R.; Stanislowski, J.J.; Erickson, T.A.; Schmidt, D.D. The Center for Air Toxic Metals (CATM) Database. In *Proceedings of the Air Quality: Mercury, Trace Elements, and Particulate Matter Conference*; McLean, VA, Dec 1–4, 1998.

- Daly, D.J.; Erickson, T.A.; Groenewold G.H.; Hawthorne, S.B.; Ness, R.O., Jr.; Sondreal, E.A.; Steadman, E.N.; Stepan, D.J. Dynamic Partnership: A New Approach to EM Technology Commercialization and Deployment. Presented at Spectrum '96 – Nuclear and Hazardous Waste Management International Topical Meeting (American Nuclear Society), Seattle, WA, Aug 18–23, 1996.

- Erickson, T.A.; Brekke, D.W.; Botros, P.E. Assessment of HAPs Emissions from Advanced Power Systems. Presented at the Advanced Coal-Fired Power Systems ‘96 Contractor’s Review Meeting, Morgantown, WV, July 16–18, 1996.

- Collings, M.E.; Erickson, T.A.; Erjavec, J.; Hassett, D.J.; Hawthorne, S.B.; Katrinak K.A.; LeNore, H.C.; Louie, P.K.K.; Miller, S.J.; Ness, S.R.; Thompson, J.S.; Weber, G.F. *A Comprehensive Assessment of Toxic Emissions from Coal-Fired Power Plants: Phase I Results from the U.S. Department of Energy Study*; Summary Report for Subtask 2.3.3; July 1995.

- Erickson, T.A.; O'Leary, E.M.; Folkedahl, B.C.; Ramanathan, M.; Zygarlicke, C.J.; Steadman, E.N.; Hurley, J.P.; Benson, S.A. Coal Ash Behavior and Management Tools. In *Proceedings of the Engineering Foundation Conference—The Impact of Ash Deposition on Coal Fired Plants*; June 20–25, 1993, Williamson, J.; Wigley, F., Eds.; Taylor & Francis: Solihull, England, 1994; pp 271–282.

JAMES M. EVANS
Senior Research Advisor
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
Arlington Heights, Illinois 60004
Phone: (847) 577-5778; E-Mail: jamesmevans@lightfirst.com

Principal Areas of Expertise

Extensive experience in the management and technical aspects of environmentally related research, including in the areas of pipeline rights-of-way issues, natural gas air emissions, groundwater contamination, water contamination, waste handling, soil contamination, and synthetic fuels from coal, and broad exposure working with executive and technical industry teams, multiconsultant teams, and peer groups.

Qualifications

B.A., Chemistry, Amherst College; B.S., Chemical Engineering, Massachusetts Institute of Technology; advanced courses in Chemical Engineering, Carnegie-Mellon Technology Institute.

Professional Experience

2002–Present: Senior Research Advisor, EERC, UND. Specializes in environmental problems with emphasis on pipeline rights-of-way environmental issues, natural gas industry HAP emission reduction, occupational safety and health, computer program development, sulfur recovery, and coal gasification.

1982–2001: Senior Research Manager, GRI (Gas Research Institute) (now Gas Technology Institute), Chicago, IL. Responsible for financial and technical management of research contracts and management of a budget of $2 to $3 million per year within the Environment and Safety Department. Worked with internal GRI teams, Industry Technical Advisors and Industry Program Advisor groups. In addition to the areas outlined above he directed research in elemental mercury contamination of groundwater, coal bed methane produced water disposal, and hazardous materials to the gas industry worker.

Prior employment included Reotec, Inc, Bethesda MD (1981–1982); Enviro Control, Rockville, MD (1976–1981); NUS Corporation, Germantown, MD (1974–1976); self-employed, Moundsville, WVA (1972–1974); and Consolidation Coal Company, Research Division, Library, PA (1956–1972).

Mr. Evans also has 47 years of experience in the synthetic fuels area. This includes research, pilot plant operation, underground coal gasification, occupational health, environment, and site restoration.

Selected Publications

- Evans, J.M., D. Skinner, GTI Emissions Software in the Natural Gas Industry, Natural Gas Quality, Metering and Utilization Conference, Lake Buena Vista, Florida, March 5, 2001

- Evans, J.M., GRI Hazardous Materials Program, Southern Gas Association Safety and Health Conference, June 21-23, 2000, Lake Buena Vista, Florida

- Evans, J.M. S.N. Varadhi, C.M. Crouch, Mercury in the Natural Gas Industry, Midwestern Energy Association Fall Distribution Roundtable, November 10, 2000, St. Louis, Missouri

- Tammi, C.E., J.D. Hair, J.A. Schmidt, D.J. Cameron, E. Steel, J.M. Evans, A Comparative Assessment of Horizontal Directional Drilling and Traditional Construction Techniques for Wetland and Riparian Area Crossings in Natural Gas Pipeline Rights-of-Way, Seventh International Symposium on Environmental Concerns in Rights-of-Way Management, September 9-13, 2000. Calgary, Canada (Published)

- Reid, S, S Stoklosar, S. Metikosh, J.M. Evans, T. Huffman, Effects of Natural Gas Pipeline Water Crossing Replacement on the Benthic Invertebrate and Fish Communities of Big Darby Creek, Ohio, 7th International Symposium on Environmental Concerns in Rights-of Way Management, September 9-13, 2000, Calgary, Canada (Published)

- Magdych, B, J.M. Evans, Identifying Wetland Revegetation Goals in Pipeline Construction Rights-of-Way, 7th International Symposium on Environmental Concerns in Rights-of Way Management, September 9-13, 2000, Calgary, Canada(Published)

- Evans, J.M., Rights-of-Way Environmental Decisions: Natural gas Industry Environmental Issues, Strategies and Solutions, IGT Conference, April 25-27, 1999, Albuquerque, NM

- Evans, J.M., Science and Rights-of-Way Issues: Environment and Management in the Gas Industry, IGT Conference, January 27, 1998, Lake Buena Vista, Florida

- Evans, J.M., Green House Gas Estimation Software: GRI-GLYCalc, Petroleum Environmental Research Forum. October 14, 1998, Chicago, Illinois,

- Groenewold, G.H., J.M. Evans, Economic Handling of Coal Gasification Wastes, July 1983.

- Evans, J.M., "The Chemical Engineer's Role In Health Protection." The International Seminar on Assessment of Toxic Agents at the Workplace-Roles of Ambient and Biological Monitoring, December 8-12, 1980, Luxembourg,.

Mr. Evans has authored or co-authored 139 papers and presentations. In addition he was technical manager for 232 GRI published reports, and 23 computer programs. A complete listing may be obtained upon request.

TIMOTHY C. FALLER
Director
Hettinger Research Extension Center, North Dakota State University (NDSU)
Box 1377, Hettinger, ND 58639
Phone: (701) 567-4323

Qualifications
M.S., Animal and Range Science, NDSU, 1974; B.S., Animal Science, NDSU, 1967.

Professional Experience
Current Position: Director, Hettinger Research Extension Center, NDSU, 1969–present.

Awarded Grants: 8 Grants (listing available upon request)

Publications: Senior Author (26), Junior Author (33) (listing available upon request), T.C. Faller, Annual Field-Day Reports,1970–1998 (28)

News Releases: 23 Accepted Releases (listing available upon request)

Program Development and Activities:
- Project Leader: North Dakota Sheep School
- Coauthor: Midwest Plans Service Handbook MWPS-3
- Project Cooperator: Sheep Integrated Resource Management
- Project Leader: North Dakota Sheep Development Project

Consulting:
- Winrock Foundation, Kazakhstan, Commonwealth of Independent States
- Ministry of Agriculture, Curitiba, Brazil
- U.S. Department of Veteran's Affairs, Fargo, ND

Special Recognition
- 1996 Program Excellence Award, Extension Small Team Category, NDSU
- 1994 ASAE Blue Ribbon Award, Educational Aids
- 1992 Program Excellence Award, Extension Small Team Category, NDSU

DAVID W. FISCHER
Independent Petroleum Geologist
5749 83rd Street South, Grand Forks, North Dakota 58201
Phone: (701) 746-8509

Qualifications
M.S., University of North Dakota, 1980; B.S., North Dakota State University, 1977.

Professional Experience
1989–Present: Independent Petroleum Geologist. Responsibilities include developing, marketing, and drilling exploratory and development prospects in the Williston Basin.

1987–1992: Instructor (part-time), Geology and Petroleum Engineering Departments, North Dakota State University. Taught Geology 100 series, Glacial Geology, Stratigraphy, Petroleum Geology, and Introduction to Well Log Analysis.

1983–1989: Subsurface Geologist, North Dakota Geological Survey. Conducted regional geological studies and monitored industry activity in the Williston Basin.

1982: Instructor (evenings), Red Rocks Community College of Denver; State of Colorado Vocational Teaching Credential. Taught Petroleum Technology.

1981–1983: Staff Geologist; Supron Energy, Denver, Colorado. Managed the Williston Basin exploratory and development program and staff, which included the drilling of over one dozen wells. Developed wildcat prospects. Supron energy was purchased by Union Texas Petroleum in 1982.

1980–1981: Exploration Geologist; Gulf Oil Corporation. Performed wildcat prospect generation and wildcat well site duty, monitored and evaluated numerous partner-operated wells drilled on Gulf acreage, and performed acreage evaluation for purchase and renewal or farmout.

Relevant Publications
- Fischer, D.W., and Anderson, S.B., 1984, Little Known Mid-Paleozoic Salts of Northwestern North Dakota: NDGS Report of Investigation No. 83.

- Gosnold, W.D., and Fischer, D.W., 1985, Heatflow and Geothermal Studies in the Great Plains: Interstate Oil Compact Commission Committee Bulletin; Vol. 27, No. 2, p. 19–26.

- Fischer, D.W., and Bluemle, J.P., 1986, Oil Exploration and Development in the North Dakota Williston Basin: 1984-1985 Update: NDGS Miscellaneous Series No. 67.

- Gosnold, W.D., and Fischer, D.W., 1986, Heat Flow in Sedimentary Basins: in Burrus, J., ed., Thermal Modeling in Sedimentary Basins; 1st Institut Francais Du Petrole Exploration Research Conference; Editions Technip Colloques et Seminaires, No. 44.

- Moore, W.L., Fischer, D.W., and Anderson, S.B., 1987, Isopach Map: Inyan Kara Formation, North Dakota: NDGS Miscellaneous Map No. 27.

- Pilatzke, R.H., Pilatzke, C.L., and Fischer, D.W., 1987, Duperow (Devonian) Productive Zones in the Williston Basin: RMAG Symposium.

- Gerhard, L.C., Fischer, D.W., and Sites, B.A., 1987, The Serendipity Factor in Petroleum Exploration, A Case Study for Deep Drilling in North Dakota: Oil and Gas Journal.

- Fischer, D.W., and Burke, R.B., 1987, A Synoptic Overview of Winnipegosis Pinnacle Reefs in North Dakota: NDGS Miscellaneous Series No. 68.

- Fischer, D.W., editor, 1987, 5th International Williston Basin Symposium Core Workshop Volume: NDGS Miscellaneous Series No. 69.

- Fischer, D.W., and Bluemle, J.P., 1988, Oil Exploration and Development in the North Dakota Williston Basin; 1986-1987 Update: NDGS Miscellaneous series No. 72.

- Gerhard, L.C., Anderson, S.B., and Fischer, D.W., 1989, Petroleum Geology of the Williston Basin; AAPG Petroleum Basin Series, Cratonic Sag Volume.

- Fischer, D.W., Gerhard, L.C., and Heck, T.C., 1990, Medicine Pole Hills Field, in: Beaumont, E. A., and Foster, N. L., eds., Treatise on Petroleum Geology, Oil Field Atlas; Stratigraphic Traps I: American Association of Petroleum Geologists.

- Borchert, R., Gerhard, L.C., Fischer, D.W., and Johnson, R.P., 1990, Glenburn Field, in: Beaumont, E. A., and Foster, N. L., eds., Treatise on Petroleum Geology, Oil Field atlas; Stratigraphic Traps I; American Association of Petroleum Geologists.

- Ogelsby, C. A., Fischer, D. W., Sedimentology and Petroleum Geology of a Triassic Spearfish Sandstone Reservoir, South Starbuck Field, Bottineau County, North Dakota, in : Christopher, J. E., and Haidl, F., eds., 6th International Williston Basin Symposium; Saskatchewan Geological Survey Special publication, No. 11, 1991.

- Fischer, D. W., LeFever, J. A., Heck, T. C., LeFever, R. D., Petroleum Geology of the Little Missouri National Grasslands: NDGS Report of Investigation No. 91, 1991.

- LeFever, J. A., Halbura, S. P., Fischer, D. W, Martinuk, C. D., North Dakota's Dickinson Lodgepole Discovery, A Preliminary Exploration Model: Oil and Gas Journal, 1995.

JOHN A. HARJU
Associate Director for Research
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5157; Fax: (701) 777-5181; E-Mail: jharju@undeerc.org

Principal Areas of Expertise
Waste management, environmental geochemistry, technology development, hydrology, and analytical chemistry, especially as applied to the upstream oil and gas industry.

Qualifications
B.S., Geology, UND; Postgraduate course work in management, economics, marketing, education, climatology, weathering and soils, geochemistry, geochemical modeling, hydrogeochemistry, hydrogeology, contaminant hydrogeology, advanced physical hydrogeology, and geostatistics.

Professional Experience
2003–Present: Associate Director for Research, EERC, UND. Responsibilities include developing and administering environmental programs involving water management and contamination cleanup and building industry–government–academic teams to carry out research, development, demonstration, and commercialization of environmental products and technologies.

2002–2003: Senior Research Advisor, EERC, UND. Responsibilities included development, marketing, management, and dissemination of market-oriented research; development of programs focused on the environmental and health effects of power and natural resource production, contaminant cleanup, water management, and analytical techniques; publication and presentation of results; client interactions; and advisor to internal staff.

1999–2002: Vice President, Crystal Solutions, LLC, Laramie, WY. Mr. Harju's firm was involved in commercial E&P produced water management, regulatory permitting and compliance, and environmental impact monitoring and analysis.

2000–2002: Principal Scientist, Produced Water Management, Gas Research Institute (GRI) (now Gas Technology Institute [GTI]), Chicago, IL. Responsibilities included development and deployment of produced water management technologies and methodologies for cost-effective and environmentally responsible management of oil and gas produced water.

1998–2000: Program Team Leader, Soil, Water, and Waste, GRI/GTI, Chicago, IL. Responsibilities included project and program management related to the development of environmental technologies and informational products related to the North American oil and gas industry; formulation of RFPs, proposal review, and contract formulation; technology transfer activities; and staff and contractor supervision. Served as Manager of the Environmentally Acceptable Endpoints project, a multiyear, $8MM effort focused on a rigorous determination of appropriate cleanup levels for hydrocarbons and other energy-derived

contaminants in soils. Also led GRI/GTI involvement with numerous industry environmental consortia and organizations, including PERF, SPE, AGA, IPEC, and API.

1997–1998: Principal Technology Manager, Soil and Water Quality, GRI/GTI, Chicago, Illinois.

1997: Associate Technology Manager, Soil and Water Quality, GRI/GTI, Chicago, Illinois.

1994–1996: Senior Research Manager, Oil and Gas Group, EERC, UND. Responsibilities included the following:

- Program Manager (PM) for program to assess the environmental transport and fate of oil- and gas-derived contaminants, focused on mercury and sweetening and dehydration processes.
- PM for field demonstration of innovative produced water treatment technology using freeze crystallization and evaporation at oil and gas industry site.
- PM for environmental transport and fate assessment of MEA and its degradation compounds at Canadian sour gas-processing site.
- PM for demonstration of unique design for oil and gas surface impoundments.
- Director, National Mine Land Reclamation Center – Western Region.
- Co-Principal Investigator on project exploring feasibility of underground coal gasification in southern Thailand.
- Consultant to International Atomic Energy Agency for program entitled "Solid Wastes and Disposal Methods Associated with Electricity Generation Fuel Chains."

1994: Research Manager, EERC, UND.

1990–1994: Hydrogeologist, EERC, UND.

1989–1990: Research Specialist, EERC, UND.

1988–1989: Laboratory Technician, EERC, UND.

Professional Memberships

- Rocky Mountain Association of Geologists

Relevant Publications

- Harju, J.A., 2001, The FTE® process – commercial deployment in the Rockies: GasTIPS Fall 2001 Issue, Chicago, Illinois, Gas Technology Institute, p. 25–28.

- Sorensen, J.A., Gallagher, J.R., and Harju, J.A., 2000, Subsurface environmental issues at natural gas dehydration sites: Biodegradability of glycol-related wastes: 7th Annual International Petroleum Environmental Conference, Albuquerque, New Mexico, November 6–8, 2000.

- Harju, John A., 2000, Overview of environmentally acceptable endpoints (EAE) research: EPRI–Gas Research Institute (GRI) Conference on the Management of Former MGP Sites, New Orleans, Louisiana, May 31 – June 2, 2000.

- Nelson, M., Legrand, R., Morecraft, A., and Harju, J., 1999, Full-scale in situ cometabolic bioremediation at a pipeline site: In Engineered approaches for in situ bioremediation of chlorinated solvent contamination, Proceedings of In Situ and On-Site Remediation, 5th International Symposium, Battelle, San Diego, CA, April 1999, Columbus, Ohio, Battelle Press, p. 113–120.

- Nakles, D.V., and Harju, J.A., 1999, Rationale, history, and policy implications of environmentally acceptable endpoints (EAEs): 9th Annual West Coast Conference on Contaminated Soils and Water, Association for the Environmental Health of Soils, Oxnard, California, March 8–11, 1999.

- Harju, J.A., Nakles, D.V., DeVaull, G., and Hopkins, H., 1999, Application of risk-based approaches for the management of E&P sites: 1999 Society of Petroleum Engineers (SPE)–U.S. Environmental Protection Agency (EPA) Exploration and Production Environmental Conference, Austin, Texas, February 28 – March 3, 1999, SPE 52723.

- Nakles, D.V., and Harju, J.A., 1998, Sequestration of contaminants in soil – State of the science: Proceedings of IGT–GRI Environmental Biotechnologies & Site Remediation Technologies, Orlando, Florida, December 7–9, 1998.

- Boysen, J., Solc, J., Schmit, C.R., Harju, J.A., Young, B.C., Canfield, M., and Kühnel, R., 1997, A feasibility study for underground coal gasification at the Krabi Coal Mine site, Thailand: Final report to the Electricity Generating Authority of Thailand, 67 p., 19 appendices.

- Sorensen, J.A., Harju, J.A., Kühnel, V., and Charlton, D.S., 1996, Field studies of the occurrence, transport, and fate of mercury at gas metering sites: Gas Research Institute, GRI-95/0143, Chicago, Illinois, 71 p., 2 appendices.

- Harju, J.A., Charlton, D.S., Stepan, D.J., Schmit, C.R., and Daly, D.J., 1995, Environmental management research initiatives within the oil and gas industry: Presented at the Symposium on Western Hemisphere Water Resources, Houston, Texas, and Cancun, Mexico, November 1995.

- Harju, J.A., and Schmit, C.R., 1993, An overview of the subsurface transport and fate of constituents associated with gas industry operations: Chicago, Illinois, Gas Research Institute, GRI-92/0477, 25 p., 2 appendices.

DR. STEVEN B. HAWTHORNE
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax: (701) 777-5181; E-Mail: shawthorne@undeerc.org

Principal Areas of Expertise
Supercritical and subcritical fluid extraction and environmental chemistry and analysis. Recent projects focus on the development of superheated water destruction methods for organic pollutants, determination of supercritical CO_2 extraction mechanisms, and the development of simple chemical tests to determine the availability of environmentally aged pollutants.

Qualifications
Ph.D., Analytical Chemistry, University of Colorado (Boulder), 1984, dissertation: "The Emission of Organic Compounds from Shale Oil Wastewaters"; M.S., Analytical Chemistry, South Dakota State University, 1978, thesis: "Specificity of Antisera Against Hordeum Vulgare Ribonuclease and Serological Quantitation of the Enzyme in Tissue Extracts"; B.S., Chemistry, South Dakota State University, 1976.

Professional Experience
1984–Present: Senior Research Manager, Environmental Chemistry, EERC, UND.

1994–Present: Adjunct Professor, Member of the Graduate Faculty, Department of Chemistry, UND.

1992: Visiting Researcher, University of Helsinki, Finland (with Professor Marja-Liisa Riekkola).

1990: Visiting Researcher, Department of Chemistry, University of Leeds, England (with Professors Keith Bartle and Anthony Clifford).

Professional Honors
- The Keene P. Dimick Award for Outstanding Accomplishments in Chromatography presented at The Pittsburgh Conference (1995)
- 5th International Symposium on Supercritical Fluid Chromatography and Extraction *Award of Excellence* for "Pioneering achievements in the development of analytical supercritical fluid technology" (1994)
- ISCO Award for Significant Contributions to Instrumentation for Separations (1993)
- U.S. Department of Energy Distinguished Lecturer (1991)

Invited Lectures
- Over 150 invited lectures since 1990 in the United States, Canada, Europe, Australia, New Zealand, and the Far East.

Recent Relevant Peer-Reviewed Publications (ca. 100 since 1990)

- Hawthorne, S.B.; Miller, D.J. Evidence for Very Tight Sequestration of BTEX Compounds in Manufactured Gas Plant Soils Based on Selective Supercritical Fluid Extraction and Soil/Water Partitioning, submitted for publication in *Environ. Sci. Technol.*

- Kubátová, A.; Jansen, B.; Vaudoisot, J.-F.; Hawthorne, S.B. Thermodynamic and Kinetic Models for the Extraction of Essential Oil from Savory and PAHs from Soil with Hot (Subcritical) Water and Supercritical CO_2. *J. Chromatogr.* **2002**, *975*, 175–188.

- Hawthorne, S.B.; Poppendieck, D.G.; Grabanski, C.B.; Loehr, R.C. Comparing PAH Availability from Manufactured Gas Plant Soils and Sediments with Chemical and Biological Tests: Part I-PAH Release During Water Desorption and Supercritical Carbon Dioxide Extraction, *Environ. Sci. Technol.* **2002**, *36*, 4795–4803.

- Kubátová, A.; Lagadec, A.J.M.; Hawthorne, S.B. Dechlorination of Lindane, Dieldrin, Tetrachloroethane, Trichloroethene, and PVC in Subcritical Water, *Environ. Sci. Technol.* **2002**, *36*, 1337–1343.

- Hawthorne, S.B.; Poppendieck, D.G.; Grabanski, C.B.; Loehr, R.C. PAH Release During Water Desorption, Supercritical Carbon Dioxide Extraction, and Field Bioremediation, *Environ. Sci. Technol.* **2001**, *35*, 4577–4583.

- Hawthorne, S.B.; Grabanski, C.B. Correlating Selective Supercritical Fluid Extraction with Bioremediation Behavior of PAHs in a Field Treatment Plot. *Environ. Sci. Technol.* **2000**, *34*, 4103–4110.

- Hawthorne, S.B.; Lagadec, A.J.M.; Kalderis, D.; Lilke, A.V.; Miller, D.J. Pilot-Scale Destruction of TNT, RDX, and HMX on Contaminated Soils Using Subcritical Water. *Environ. Sci. Technol.* **2000**, *34*, 3224–3228.

- Windal, I.; Miller, D.J.; De Pauw, E.; Hawthorne, S.B. Supercritical Fluid Extraction and Accelerated Solvent Extraction of Dioxins from High- and Low-Carbon Fly Ash. *Anal. Chem.* **2000**, *72*, 3916–3921.

- Hawthorne, S.B.; Grabanski, C.B.; Martin, E.; Miller, D.J. Comparisons of Soxhlet Extraction, Pressurized Liquid Extraction, Supercritical Fluid Extraction and Subcritical Water Extraction for Environmental Solids: Recovery, Selectivity and Effects on Sample Matrix. *J. Chromatogr. A* **2000**, *892*, 421–433.

- Lagadec, A.J.M.; Miller, D.J.; Lilke, A.V.; Hawthorne, S.B. Pilot-Scale Subcritical Water Remediation of Polycyclic Aromatic Hydrocarbon- and Pesticide-Contaminated Soil. *Environ. Sci. Technol*. **2000**, *34*, 1542–1548.

- Pilorz, K.; Björklund, Bøwadt, S.; Mathiasson, L.; Hawthorne, S.B. Determining PCB Sorption/ Desorption Behavior on Sediments Using Selective Supercritical Fluid Extraction:

Part II, Describing PCB Extraction with Simple Diffusion Models. *Environ. Sci. Technol.* **1999**, *33*, 2204–2212.

- Björklund, E.; Bøwadt, S.; Mathiasson, L.; Hawthorne, S.B. Determining PCB Sorption/ Desorption Behavior on Sediments Using Selective Supercritical Fluid Extraction: Part I, Desorption from Historically Contaminated Samples. *Environ. Sci. Technol.* **1999**, *33*, 2193–2203.

DENNIS L. LAUDAL
Senior Research Advisor
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax: (701) 777-5181; E-Mail: dlaudal@undeerc.org

Principal Areas of Expertise

Principal areas of expertise include measurement and characterization of coal-fired combustion system emissions. Mr. Laudal is considered a leading expert on continuous emission monitors for mercury and other air toxics. Other areas of expertise include particulate characterization and control, control measurement of SO_x/NO_x and air toxics, fluidized-bed combustion, and preparation and analysis of combustion fuels.

Qualifications

M.S., Chemical Engineering, UND, 1984; B.A., Chemistry and Biology, Concordia College, 1974.

Professional Experience

2001–Present: Senior Research Advisor, EERC, UND. Primary responsibility is program development and management at the EERC, primarily related to air toxics control and measurement. Has been directly responsible for large, multipartner projects at the bench-, pilot-, and field-scale level, including development of project quality plans, project oversight, research analysis, and reporting, as well as developing work plans and budgets for future projects for the past 9 years.

1994–2001: Research Manager, Gas Cleanup Technologies, EERC, UND. Responsibilities include the direct supervision of personnel involved in flue gas cleanup research programs at the EERC as well as planning, implementation, supervision, and reporting of research projects involving field- and pilot-scale studies. Has directed large-scale research programs at the EERC for the past 8 years.

1984–1994: Research Engineer, Gas Stream Cleanup Systems, EERC, UND. Responsibilities included planning, implementation, and supervision of tests conducted on a pilot-scale pc-fired combustor and catalytic fabric filtration research. He performed particle sampling and sizing, including EPA-5 dust loading, impactors, SASS train, multicyclone, and laser particle-size analysis and performed EPA wet tests for flue gas analysis. Other work included computer-aided data analysis and equipment design.

Relevant Publications

- Laudal, D.L. *Evaluation of Aerosol Emissions Downstream of an Ammonia-Based SO_2 Scrubber (Evaluation of a Wet ESP for Reducing SO_3 Aerosol Emissions)*; Final Report (March 15, 2001 – June 30, 2002) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-98FT40321; EERC Publication 2002-EERC-04-02; Energy & Environmental Research Center: Grand Forks, ND, April 2002.

- Laudal, D.L.; Thompson, J.S.; Pavlish, J.H.; Brickett, L.; Chu, P.; Srivastava, R.K.; Lee, C.W.; Kilgroe, J. *Selective Catalytic Reduction Mercury Field Sampling Project;* Final Report for U.S. Department of Energy Cooperative Agreement No. DE-FC26-98FT40321, U.S. Environmental Protection Agency Cooperative Agreement No. 92935301, and EPRI Contract No. EP-P5248/C2595; Energy & Environmental Research Center: Grand Forks, ND, 2002.

  — Also in Power Plant Evaluation of the Effect of Selective Catalytic Reduction in Mercury, EPRI, Palo Alto, CA, U.S. Department of Energy, Pittsburgh, PA, and U.S. Environmental Protection Agency, Research Triangle Park, NC: 2002. 1005400.

- Laudal, D.L.; Ondov, J.M.; Terry, J.S.; Heller-Zeisler, S. *Determination of Particulate Deposition Parameters Using A Novel Dual-Tracer Method: Phase I*; Combined Annual and Final Report (Sept 30, 1998 – Sept 30, 2000) for EPA Grant Nos. X985891-01 and X995129-01; EERC Publication 2000-EERC-09-01, Energy & Environmental Research Center: Grand Forks, ND, Sept 2000.

- Laudal, D.L; Kurz, M.D.; Sorensen, J.A.; Bolles, B.A.; Gunderson, L.L. *Mercury Formation and Fate*; Final Report for EPRI Purchase Order No. WO9002-23, Cooperative Power Association Purchase Order No. PO2002350-000, Minnkota Power Cooperative Purchase Order No. PO 97-4630, U.S. Department of Energy Contract No. DE-FC21-93MC30098, and Industrial Commission of North Dakota Purchase Order No. FY98-XXVIII-79; EERC Publication 99-EERC-01-02, Energy & Environmental Research Center: Grand Forks, ND, Jan 1999.

- Laudal, D.L.; Heidt, M.K. *Evaluation of Flue Gas Mercury Speciation Method*; Final Report for EPRI No. 108988; U.S. Department of Energy Contract No. DE-FC21-93MC30098; Energy & Environmental Research Center: Grand Forks, ND,, Nov 1997.

- Miller, S.J.; Dunham, G.E.; Laudal, D.L.; Heidt, M.K. On-Line Process Monitoring with the Combined Aerodynamic Particle Size and Scanning Mobility Particle Sizer. In *Proceedings of the PARTEC 95; 6th European Symposium Particle Characterization*; Nürnberg, Germany, March 1995; pp 401–409, preprint.

- Miller, S.J.; Laudal, D.L. *Pulse-Jet Baghouse Performance Improvement with Flue Gas Conditioning*; Final Project Report for EPRI, the U.S. Department of Energy, and the Canadian Electrical Association; Energy & Environmental Research Center: Grand Forks, ND, Oct 1992.

DR. F. (FREDRICK) LARRY LEISTRITZ
Distinguished Professor of Agricultural Economics
Department of Agricultural Economics, North Dakota State University (NDSU)
Fargo, North Dakota 58105
Phone: (701) 231-7455; Fax: (701) 231-7400; E-Mail:

Qualifications
Ph.D., M.S., B.S., Agricultural Economics, University of Nebraska, Lincoln.

Professional Experience
- Distinguished Professor of Agricultural Economics, NDSU.

- International Association for Impact Assessment – President, 1993–1994; Program Chair, 1991 Annual Conference; Director, 1985–1988

- Western Agricultural Economics Association – President, 1985–1986; Director, WAEA Executive Council, 1981–1983; Member of Editorial Council of *Western Journal of Agricultural Economics*, 1976–1978 and 1982–1985

- American Agricultural Economics Association – Chair, Selected Posters, 1991 Annual Meetings

Honors and Awards
- Business and Industrial Development Award, Greater North Dakota Association, 1998

- Faculty Economic Development Award, NDSU, 1995

- Fargo Chamber of Commerce, NDSU Distinguished Professorship, 1994

- Excellence in Research Award, Senior Faculty, North Dakota Agricultural Experiment Station, NDSU, 1993

Research
Dr. Leistritz has authored more than 400 research publications, including more than 100 refereed journal articles. He has directed grant and contract-funded research projects totaling more than $5 million.

ALAN C. LUKES
Vice President and Chief Operating Officer
Dakota Gasification Company
1600 East Interstate Avenue, Bismarck, North Dakota 58501-0561
Phone: (701) 221-4400; E-Mail: alukes@bepc.com

Qualifications
M.S., Chemical Engineering, Cornell University; B.S. Chemical Engineering, University of North Dakota; Registered Professional Engineer; MIT Program for Senior Executives.

Professional Experience
Vice President and Chief Operating Officer, Dakota Gasification Plant, Bismarck, North Dakota. Mr. Lukes joined Dakota Gasification as Plant Manager upon the acquisition of the Great Plains Synfuels Plant by Basin Electric in 1988.

Operations Manager, Great Plains Synfuels Plant, Beulah, North Dakota. Mr. Lukes was integral in the management team that built the unique Great Plains Synfuels Plant facility on time and under budget, a facility which throughout its history has demonstrated repeated technical and operational breakthroughs and successes. He served as Operations Manager until his advancement to Plant Manager in 1988.

Plant Manager, Air Products & Chemicals, Inc., New Orleans, Louisiana. Mr. Lukes managed the ammonia, carbon dioxide, hydrogen and industrial gases complex.

Dow Chemical Company, Michigan. Mr. Lukes' responsibilities spanned various engineering and production management positions in the Hydrocarbons Department.

Professional Memberships
- American Institute of Chemical Engineering
- American Chemical Society

MARK A. MUSICH
Research Engineer
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax: (701) 777-5181; E-Mail: mmusich@undeerc.org

Principal Areas of Expertise
Development and operation of fossil and biomass fuel conversion systems such as fluid-bed and entrained-flow gasifiers and liquid- and solid-phase beneficiation processes, including agglomeration, hydrothermal and thermal treatment, and chemical and physical cleaning.

Qualifications
M.S., Chemical Engineering, UND, 1986; B.S., Chemical Engineering, UND, 1983.

Professional Experience
1999–Present: Research Engineer, Advanced Process and Chemistry Group, EERC, UND. Responsibilities include design and development of systems for feeding fossil and biomass fuels to high-pressure gasifiers, development of systems for improving handling and stability of biomass fuels, experimental design and data evaluation, development and operation of fuel conversion and upgrading processes, and preparation of reports and proposals.

1996–1999: Research Manager, Systems Analysis, EERC, UND. Responsibilities included supervision of Systems Analysis personnel; applying software engineering tools for the simulation and economic evaluation of chemical processes; performing critical review of SE studies; applying SE methodology and decision-making tools to the design, development, and implementation of chemical processing technologies and systems.

1991–1996: Research Engineer/Supervisor, Coal Beneficiation, EERC, UND. Responsibilities include experimental design and data evaluation, supervision of beneficiation and briquetting test programs, development of beneficiation processes, analytical and product evaluation techniques, beneficiation personnel supervision, preparation of reports and proposals, and preparation and presentation of papers.

1989–1991: Research Engineer, Fuels Beneficiation/Fuels Preparation, EERC, UND. Responsibilities included the operation and maintenance of bench- and pilot-scale hydrothermal drying processes; operation of pilot-scale coal cleaning processes; and design, performance, and evaluation of beneficiation experiments; report writing; and proposal solicitation.

1988–1989: Research Engineer, Mild Gasification, EERC, UND. Responsibilities included the design and material specifications for the construction of a 100-lb/hr spout-fluid-bed reactor for the low-temperature gasification of carbonaceous feedstocks.

1987–1988: Contract Research Engineer, Great Plains Coal Gasification Company, Beulah, North Dakota. Responsibilities included the operation and maintenance of a demonstration scale sour-gas scrubbing unit for the removal of SO_2, design of test matrices, evaluation of the test data, and preparation of reports.

1986–1987: Research Engineer, Hydrogen Production, EERC, UND. Responsibilities included the design, construction, and operation of a 40-lb/hr fluidized-bed reactor for the catalytic gasification of carbonaceous feedstocks; data reduction; and report writing.

Professional Memberships

- American Institute of Chemical Engineers

Relevant Publications

- Zygarlicke, C.J.; Olson, E.S.; Sorensen, J.A.; Stepan, D.J.; Swanson, M.L.; Folkedahl, B.C.; Musich, M.A.; Schmidt, D.D. *EERC Biomass Utilization Program*; Final Report for Year 1 2001-2002 (July 1, 2001 - Sept 2002) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-01NT4119; EERC Publication 2003-EERC-01-03; Energy & Environmental Research Center: Grand Forks, ND, Jan 2003.

- Zygarlicke, C.J.; McCollor, D.P.; Eylands, K.E.; Hetland, M.D.; Musich, M.A.; Crocker, C.R.; Dahl, J.; Laducer, S. *Impacts of Cofiring Biomass with Fossil Fuels*; Final Report (April 1, 1999 – March 31, 2001) for U.S. Department of Energy Contract No. DE-FC26-98FT40320; EERC Publication 2001-EERC-08-03; Energy & Environmental Research Center: Grand Forks, ND, Aug 2001.

- Zygarlicke, C.J.; Eylands, K.E.; McCollor, D.P.; Musich, M.A.; Toman, D.L. Impacts of Cofiring Biomass with Fossil Fuels. In *Proceedings of the 25th International Technical Conference on Coal Utilization and Fuel Systems*; Clearwater, FL, March 6–9, 2000; pp 115–126.

DR. CHARLES R. NELSON
Petroleum Geochemist
1849 Denver West Drive, Apt. 2325, Golden, Colorado 80401-3149
Phone: (303) 216-9059; E-Mail: charles.nelson2@worldnet.att.net

Principal Areas of Expertise
Petroleum geochemist with 22 years of industry work experience. Career focus on evaluating coalbed and shale gas resource and reservoir properties, coal geochemistry, and geologic CO_2 sequestration.

Qualifications
Ph.D., Organic Chemistry, North Carolina State University (NCSU), Raleigh, 1976; M.S., Organic Chemistry, University of Montana, Missoula, 1973; B.S. Wood Science and Technology, NCSU, 1970.

Professional Experience
2003–Present: Research Advisor, Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND. Provide technical guidance and support for coalbed gas resource evaluation and geologic CO_2 sequestration projects.

1999–2003: Short Course Instructor, University of Alabama, Tuscaloosa, AL. Teach short courses on coalbed reservoir property analysis.

2001–2002: Chief Scientist, GTI E&P Services and TICORA Geosciences, Arvada, CO. Conducted evaluations of coalbed reservoir properties for gas company clients; prepared technical reports, reservoir property databases, and analysis protocols; and developed and taught training courses on analysis of coalbed reservoir properties.

1981–2000: Geoscientist/Project Manager, Gas Research Institute, Chicago, IL. Developed and managed $1.5 million/year research programs on coal and biomass gasification chemistry and analysis of coalbed and shale gas reservoir properties; prepared reservoir property databases, resource maps, and technical reports; developed analysis protocols for evaluating coalbed reservoir properties; and developed and taught training courses on analysis of coalbed reservoir properties.

1980–1981: Research Chemist, U.S. Department of Agriculture Forest Products Laboratory, Madison, WI. Conducted research on the chemical modification of wood properties.

1978–1979: Postdoctoral Research Associate, Massachusetts Institute of Technology, Cambridge, MA. Conducted environmental geochemistry research to identify the sources of industrial organic compounds in sediment samples collected from U.S. rivers.

1976–1978: Visiting Research Scientist, STFI-Royal Institute of Technology, Stockholm, Sweden. Conducted research on the chemistry of lignin depolymerization.

Professional Memberships
- American Chemical Society
- American Association of Petroleum Geologists
- Society of Petroleum Engineers

Professional Activities
- Reviewer for DOE, NSF, ACS-Petroleum Research Fund, and scientific journals.
- International Coalbed Methane Symposium Executive Committee (1996–2003).
- Society of Petroleum Engineers – Emerging and Peripheral Technology Committee (1991–1994).
- Cochair International Symposium on Gasification of Chars from Carbonaceous Materials, 187th National American Chemical Society Meeting, Fuel Chemistry Division, St. Louis, MO, April 1984.

Honors and Awards
- AAPG Frank Kottlowski Memorial Presentation Award (2001 AAPG Annual Meeting)
- Honor Society of Phi Kappa Phi
- Weyerhaeuser Company Foundation Fellowship (1974–1976)
- EPA Traineeship (1974)

Relevant Publications
- Nelson, C.R. Reservoir Property Analysis Methods for Low Gas Content, Subbituminous Coals. In *Proceedings of the 2003 International Coalbed Methane Symposium*; University of Alabama, Tuscaloosa, AL, May 5–9, 2003, in press, 14 p.

- Nelson, C.R. *North American Coalbed Methane Resource Map*; Gas Technology Institute Report GTI-01/0165; Gas Technology Institute: Des Plaines, IL, 2001.

- Nelson, C.R. Geologic Controls on Effective Cleat Porosity Variation in San Juan Basin Fruitland Formation Coalbed Reservoirs. In *Proceedings of the 2001 International Coalbed Methane Symposium*; University of Alabama, Tuscaloosa, AL, May 14–18, 2001; pp 11–19.

- Nelson, C.R.; Pratt, T.J. Understanding Reservoir Properties Key to Coalbed Gas Success. *Am. Oil Gas Report*. **2001**, *44* (3), 78–87.

- Nelson, C.R. New Methods for Coalbed Reservoir Gas-In-Place Analysis: Results from Studies in the San Juan, Powder River, Black Warrior and Central Appalachian Basins. In *Proceedings of the PTTC Conference on Innovative Technology for Coal Bed Methane in the Appalachian Basin*; Daniels, WV, Sept 13, 2000; 12 p.

- Nelson, C.R. Coalbed Methane Potential of the U.S. Rocky Mountain Region. *GasTIPS* **2000**, *6* (3); Gas Technology Institute: Chicago, IL, pp 4–12.

- Hill, D.G.; Nelson, C.R. *United States Fractured Shale Gas Resource Map*; Gas Research Institute Report GRI-00/0111; Gas Research Institute: Chicago, IL, 2000.

- Hill, D.G.; Nelson, C.R. Gas Productive Fractured Shales: An Overview and Update. *GasTIPS* **2000**, *6* (2); Gas Research Institute: Chicago, IL, pp 4–13.

- Hill, D.G.; Nelson, C.R.; Brandenburg, C.F. Coalbed Methane in the Rocky Mountain Region: The Old, the New, and the Future. In *Proceedings of the Coalbed Methane in the Rocky Mountains*; Denver, CO, June 20–21, 2000; pp 1–5.

- Hill, D.G.; Nelson, C.R.; Brandenburg, C.F. Coalbed Methane "Frontier" Expanding. *Am. Oil Gas Report*. **2000**, *43* (5), 83–85.

- Nelson, C.R. Effects of Geologic Variables on Cleat Porosity Trends in Coalbed Gas Reservoirs. Presented at the 2000 SPE/CERI Gas Technology Symposium, Calgary, Alberta, Canada, April 3–5, 2000, Paper 59787.

- Nelson, C.R.; Hill, D.G.; Pratt, T.J. Properties of Paleocene Fort Union Formation Canyon Seam Coal at the Triton Federal Coalbed Methane Well, Campbell County, Wyoming. Presented at the 2000 SPE/CERI Gas Technology Symposium, Calgary, Alberta, Canada, April 3–5, 2000; Paper 59786.

- Nelson, C.R. *Gas Research Institute North American Coalbed Methane Resource Map*; Gas Research Institute Report GRI-99/0131; Gas Research Institute: Chicago, IL, 1999.

- Nelson, C.R. Effects of Coalbed Reservoir Property Analysis Methods on Gas-In-Place Estimates. Presented at the 1999 SPE Eastern Regional Meeting, Charleston, WV, Oct 20–22, 1999; Paper SPE 57443.

- Nelson, C.R. Changing Perceptions Regarding the Size and Production Potential of Coalbed Methane Resources. *GasTIPS* **1999**, *5* (2), 4–11; Gas Research Institute: Chicago, IL.

- Nelson, C.R. Critical Assessment of Coalbed Reservoir Gas-In-Place Analysis Methods.In *Proceedings of the 1999 International Coalbed Methane Symposium*, University of Alabama, Tuscaloosa, AL, May 3–7, 1999; pp 77–90.

- Nelson, C.R. Gem in the Rough – Technology, Economics Putting New Shine on Coalbed Methane. *Am. Oil Gas Report*. **1999**, *42* (3), 85–92.

- Nelson, C.R. Advances in Coalbed Reservoir Gas-In-Place Analysis. *GasTIPS* **1997/1998**, *4* (1), 14–19; Gas Research Institute: Chicago, IL.

- Nelson, C.R.; Li, W.; Lazar, I.M.; Larson, K.H.; Malik, A.; Lee, M.L. Geochemical Significance of n-Alkane Compositional-Trait Variations in Coals. *Energy Fuels* **1998**, *12*, 277–283.

- Mavor, M.J.; Nelson, C.R. *Coalbed Reservoir Gas-In-Place Analysis*; Gas Research Institute Report GRI-97/0263; Gas Research Institute: Chicago, IL, 1997; 144 p.

- Nelson, C.R.; Mavor, M.J.; Pratt, T.J.; Casey, T.A. Protocol Ups Coal Seam Gas Analysis. *Am. Oil Gas Report*. **1997**, *40* (10), 86–89.

- Nelson, C.R.; Li, W.; Lazar, I.M.; Malik, A.; Lee, M.L. Effects of Geologic Variables on Light Oil Co-Production from Coal Seam Gas Reservoirs. In *Proceedings of the 1997 Rocky Mountain Section Meeting, American Association of Petroleum Geologists*; Denver, CO, Aug 24–27, 1997; pp 121–124.

- Nelson, C.R.; Li, W.; Lazar, I.M.; Malik, A.; Lee, M.L. Influence of Geologic Variables on the Content of Light Oil in U.S. Coals. In *Proceedings of the 1997 International Coalbed Methane Symposium*; University of Alabama, Tuscaloosa, AL, May 12–16, 1997; pp 313–322.

- Mavor, M.J.; Pratt, T.J.; Nelson, C.R.; Casey, T.A. Improved Gas-In-Place Determination for Coal Gas Reservoirs. Presented at the SPE Gas Technology Symposium, Calgary, Alberta, Canada, April 28–May 1, 1996, Paper SPE 35623.

- Nelson, C.R.; Mavor, M.J. *Improved Coal Seam Reservoir Gas-In-Place Analysis Protocol*; Gas Research Institute Report GRI-96/0481; Gas Research Institute: Chicago, IL, 1996; 4 p.

- Mavor, M.J.; Pratt, T.J.; Nelson, C.R. Quantify the Accuracy of Coal Seam Gas Content. *Petroleum Eng. Int'l* **1995**, *68* (10), 37–42.

- Mavor, M.J.; Pratt, T.J.; Nelson, C.R. Quantitative Evaluation of Coal Seam Gas Content Estimate Accuracy. Presented at the SPE Rocky Mountain Regional/Low-Permeability Reservoirs Symposium, Denver, CO, March 20–22, 1995, Paper SPE 29577.

- Nelson, C.R. New Analytical Technique Developed for Measuring Trace Hydrocarbons in Sedimentary Rocks. *Gas Res. Inst. Digest* **1994**, *17* (3), 24.

- Nelson, C.R. Ed. *Chemistry of Coal Weathering*; Elsevier Science Publishers: New York, 1989; 230 p.

- Nelson, C.R. Coal Weathering: Chemical Processes and Pathways. In *Chemistry of Coal Weathering*; Nelson, C.R., Ed.; Elsevier Science Publishers: New York, 1989; pp 1–32.

- Nelson, C.R. Factors Influencing Conformational Preferences and Equilibria in Solutions of Aldono-1,5-Lactones. *Carbohydrate Res*. **1987**, *163*, 275–278.

- Nelson, C.R.; Cox, J.L. Evidence for Single Electron-Transfer Initiation of Carbon Gasification Reactions. *J. Phys. Chem*. **1985**, *89*, 892–893.

- Cox, J.L.; Nelson, C.R. Coal Weathering: Causes, Effects and Implications. *Prepr. Pap.—Am. Chem. Soc., Div. Fuel Chem*. **1984**, *29* (1), 102–107.

- Nelson, C.R. The Conformation of 2,3,4,6-Tetra-O-Acetyl-D-Glucono-1,5-Lactone. *Carbohydrate Res*. **1982**, *106*, 155–159.

- Cox, J.L.; Nelson, C.R. Perspective on Coal Samples. In *Proceedings of the DOE Basic Coal Science Workshop*; Houston, TX, Dec 8–9, 1981; pp 113–127.

- Nelson, C.R.; Hites, R.A. Aromatic Amines in and near the Buffalo River. *Environ. Sci. Technol*. **1980**, *14*, 1147–1149.

- Nelson, C.R. The Conformation of 2,3,4-Tri-O-Acetyl-D-Xyleno-1,5-Lactone. *Carbohydrate Res*. **1979**, *68*, 55–60.

- Gierer, J.; Nelson, C.R. Mechanism of Aryl Group Migration in the Formation of Stilbenes from 1,1-Bis(p-hydroxyaryl)ethane-2-O-Aryl Ethers. *J. Org. Chem*. **1978**, *43*, 4028–4032.

- Nelson, C.R.; Gratzl, J.S. The Conversion of D-Glucono-1,5-Lactone Into an a-Pyrone Derivative. *Carbohydrate Res.* **1978**, *60*, 267–273.

- Shafizadeh, F.; Lai, Y.Z.; Nelson, C.R. Thermal Degradation of 6-Chloro Carbohydrates. *J. Appl. Poly. Sci*. **1976**, *20*, 139–152.

- Nelson, C.R. Cleat Property Trends in San Juan Basin Fruitland Formation Coalbed Reservoirs. Presented at the 2002 Rocky Mountain Section Meeting, American Association of Petroleum Geologists, Laramie, WY, Sept 8–11, 2002.

- Nelson, C.R. Reservoir Property Analysis Methods for Low Gas Content Subbituminous Coals. Presented at the PTTC Denver Basin Coalbed Methane Workshop, Denver, CO, Sept 28, 2001.

- Nelson, C.R. Geologic Controls on the Carbon Dioxide Sequestration Capacity of Coal Deposits. Presented at the 2001 American Association of Petroleum Geologist Annual Convention, Denver, CO, June 3–6, 2001.

- Nelson, C.R. Geologic Controls on Effective Cleat Porosity Variation in San Juan Basin Fruitland Formation Coalbed Reservoirs. Presented at the 2001 International Coalbed Methane Symposium, University of Alabama, Tuscaloosa, AL, May 14–18, 2001.

- Nelson, C.R.; Pratt, T.J. Reservoir Properties of Paleocene Fort Union Formation Canyon Seam Coal, Campbell County, WY. Presented at the 2000 Rocky Mountain Section Meeting, American Association of Petroleum Geologists, Albuquerque, NM, Sept 17–20, 2000.

- Nelson, C.R. New Methods for Coalbed Reservoir Gas-In-Place Analysis: Results from Studies in the San Juan, Powder River, Black Warrior and Central Appalachian Basins. Presented at the PTTC Conference on Innovative Technology for Coal Bed Methane in the Appalachian Basin, Daniels, WV, Sept 13, 2000.

- Nelson, C.R. Effects of Geologic Variables on Cleat Porosity Trends in Coalbed Gas Reservoirs. Presented at the 2000 SPE/CERI Gas Technology Symposium, Calgary, Alberta, Canada, April 3–5, 2000.

- Nelson, C.R.; Hill, D.G.; Pratt, T.J. Properties of Paleocene Fort Union Formation Canyon Seam Coal at the Triton Federal Coalbed Methane Well, Campbell County, Wyoming. Presented at the 2000 SPE/CERI Gas Technology Symposium, Calgary, Alberta Canada, April 3–5, 2000.

- Nelson, C.R. Effects of Coalbed Reservoir Property Analysis Methods on Gas-In-Place Estimates. Presented at the 1999 SPE Eastern Regional Meeting, Charleston, WV, Oct 20–22, 1999.

- Nelson, C.R. Common Sources of Errors in Coalbed Gas Resource and Reservoir Property Values. Presented at the 1999 Eastern Section Meeting, American Association of Petroleum Geologists, Indianapolis, IN, Sept 18–21, 1999.

- Nelson, C.R. Critical Assessment of Coalbed Reservoir Gas-In-Place Analysis Methods. Presented at the 1999 International Coalbed Methane Symposium, University of Alabama, Tuscaloosa, AL, May 3–7, 1999.

- Nelson, C.R. Comparison of Methods for Determining Coalbed Methane Gas-In-Place. Presented at the Four Corners Oil & Gas Conference, Farmington, NM, May 5–6, 1998.

- Nelson, C.R. Coalbed Reservoir Gas-In-Place Analysis. Presented at the Wyoming Bureau of Land Management Coalbed Methane Resource Meeting, Casper, WY, March 3, 1998.

- Nelson, C.R. Geologic Controls on Effective Cleat Porosity in Coal Seam Gas Reservoirs. Presented at the 1997 Geological Society of America Annual Meeting, Salt Lake City, UT, Oct 20–23, 1997.

- Nelson, C.R.; Li, W.; Lazar, I.M.; Malik, A.; Lee, M.L. Effects of Geologic Variables on Light Oil Co-Production from Coal Seam Gas Reservoirs. Presented at the 1997 Rocky Mountain Section Meeting, American Association of Petroleum Geologists, Denver, CO, Aug 24–27, 1997.

- Nelson, C.R.; Li, W.; Lazar, I.M.; Malik, A.; Lee, M.L. Influence of Geologic Variables on the Content of Light Oil in U.S. Coals. Presented at the 1997 International Coalbed Methane Symposium, University of Alabama, Tuscaloosa, AL, May 12–16, 1997.

ERIN M. O'LEARY
Senior Research Manager, Research Information Systems
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax: (701) 777-5181; E-Mail: eoleary@undeerc.org

Principal Areas of Expertise
Management of projects that involve building databases and Web-based programs for engineering and scientific applications and information systems, including business analysis, data modeling, application design, and software development.

Qualifications
B.A., Business Administration, University of North Dakota, 1988.

Professional Experience
2002–Present: Senior Research Manager, EERC, UND. Responsible for developing proposals, securing clients, conducting research, managing research projects with multidisciplinary technical staff building databases and PC and Web-based software applications for engineering and scientific projects, writing technical reports, and managing the Research Information Systems Group, a team of programmers and database administrators developing PC and Web-based databases and applications for for research projects and for internal business functions of the EERC.

1996–2002: Manager, Information Systems, EERC, UND. Responsibilities included management of the Information Systems Group and the Resource Management Group. These groups are responsible for developing and implementing database management systems, providing mainframe computer services, providing project management support for principal investigators, and providing personnel planning and financial projections.

1994–1996: Information Technology Manager, EERC, UND. Responsibilities included evaluating, designing, implementing, and maintaining database management systems in support of research projects. In addition, duties included program development and demonstration of the database management capabilities to potential clients.

1989–1993: Research Specialist, Combustion Studies, EERC, UND. Responsibilities included information management, network administration, project budget planning and tracking, database development and maintenance, advanced data transfer, and manipulation programming.

1988–1989: Research Technician, Combustion Studies, EERC, UND. Responsibilities included assisting with budget monitoring, maintaining a database for sample tracking, assisting in data reduction, and performing literature searches.

Relevant Publications

- Reilkoff, T.E.; Hetland, M.D.; O'Leary, E.M. Review of Industries and Government Agencies for Technologies Applicable to Deactivation and Decommissioning of Nuclear Weapons Facilities. Presented at the Waste Management Symposium, Tucson, AZ, Feb 24–28, 2002.

- Reilkoff, T.E.; O'Leary, E.M. Identifying Solutions for Site Needs Using the D&D Information System and the EM Technical Assistance System. Presented at DDFA/SCFA Mid-Year Review, Salt Lake City, UT, March 4–7, 2002.

- O'Leary, E.M.; Pflughoeft-Hassett, D.F. Development of a Coal Combustion Product (CCP) Database System; Final Report for American Coal Ash Association and Task 47, U.S. Department of Energy Cooperative Agreement No. DE-FC21-93MC30098; EERC Publication 97-EERC-09-04; Energy & Environmental Research Center: Grand Forks, ND, Sept 1997.

- O'Leary, E.M.; Pflughoeft-Hassett, D.F. *ACAA CCP Data Manager User's Guide*; Version 1.0; Energy & Environmental Research Center: Grand Forks, ND, 1997.

- Peck, W.D.; O'Leary, E.M.; Erickson, T.A. Application of the Center for Air Toxic Metals (CATM) Database. *In Proceedings of the 13th Annual Pittsburgh Coal Conference*; Pittsburgh, PA, Sept 3–7, 1996; Vol. 2, pp 1350–1355.

- Erickson, T.E.; O'Leary, E.M.; Allan, S.E.; Benson, S.A. Hazardous Air Pollutants from Conventional and Advanced Coal-Fired Power Systems: A Database and Modeling Approach. Presented at the 3rd International Conference on Combustion Technologies for a Clean Environment, Lisbon, Portugal, July 3–6, 1995.

WESLEY D. PECK
Research Scientist
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax: (701) 777-5181; E-Mail: wpeck@undeerc.org

Principal Areas of Expertise
Water resource and watershed management, geographic information systems (GIS), database programming and design, computer graphics, and Web page management. Proficient in the use of ArcView® and MapInfo® GIS software, CorelDraw®, MS Access®, and spreadsheet and word-processing software.

Qualifications
M.S., Geology, UND, 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
1991–Present: Research Scientist, EERC, UND. Responsibilities include functioning as a member coordinator and assisting in research and management of activities for Red River Water Management Consortium (RRWMC) stakeholders, acquisition and management of watershed and water resource data, Web page management, organization and development of presentations and presentation graphics for the RRWMC, and report and proposal writing. Other responsibilities include management and application of GIS at the EERC, with special emphasis on energy and environmental data; serving on the Information and Education Subcommittee of the Red River Basin Riparian Project; and the development of databases and applications in the area of watershed management.

1989–1991: Graduate Research Assistant, EERC, UND. Responsibilities included acquisition, entry, and management of geologic data (locality, stratigraphic, lithologic, and geochemical information) with the Q&A® database program and developing complex programming statements with Q&A® for augmenting data management functions.

1990–1992 (summers): Field Assistant, EERC, UND. Assisted in the collection of Cretaceous and Tertiary fossils and stratigraphic information in western North Dakota and eastern Montana; collected and described well cuttings for two exploratory wells in southwestern North Dakota; and monitored shallow-well drilling activity related to an underground coal gasification project in southern Wyoming.

1987–1989: Graduate Teaching Assistant, Department of Geology and Geological Engineering, UND. Responsibilities included assisting in the teaching of introductory and historical geology, sedimentology, and petrology; assembling laboratory materials; preparing and grading tests; and tutoring.

Relevant Publications

- Energy & Environmental Research Center. *Red River Water Management Consortium Annual Report – Year 6*; Annual Report (March 2001 – Feb 2002) for the U.S. Department of Agriculture and multiple clients; Energy & Environmental Research Center: Grand Forks, ND, March 2002.

- Energy & Environmental Research Center. *Red River Water Management Consortium Annual Report – Year 5*; Annual Report (March 2000 – Feb 2001) for the U.S. Department of Agriculture and multiple clients; Energy & Environmental Research Center: Grand Forks, ND, March 2001.

- Energy & Environmental Research Center. *Red River Water Management Consortium Annual Report – Year 4*; Annual Report (March 1999 – Feb 2000) for the U.S. Department of Agriculture and multiple clients; Energy & Environmental Research Center: Grand Forks, ND, March 2000.

- Energy & Environmental Research Center. *Red River Water Management Consortium Annual Report – Year 3*; Annual Report (March 1998 – Feb 1999) for the U.S. Department of Agriculture and multiple clients; Energy & Environmental Research Center: Grand Forks, ND, March 1999.

- Moe, T.A; Peck, W.D. *HEC–RAS Modeling of the Pedestrian Bridge Between East Grand Forks and Grand Forks*; Final Report for City of Grand Forks Project No. 4949; EERC Publication No. 99-EERC-05-02; Energy & Environmental Research Center: Grand Forks, ND, May 1999.

- Energy & Environmental Research Center. *Red River Water Management Consortium Annual Report – Year 2*; Annual Report (March 1997 – Feb 1998) for the U.S. Department of Agriculture and multiple clients; Energy & Environmental Research Center: Grand Forks, ND, March 1998.

- Energy & Environmental Research Center. *Red River Water Management Consortium Annual Report – Year 1*; Annual Report (March 1996 – Feb 1997) for the U.S. Department of Agriculture and multiple clients; Energy & Environmental Research Center: Grand Forks, ND, March 1997.

- Stoa, R.S.; Peck, W.D.; Sorensen, J.A. *Development of a Natural Settings Geographic Information System Database for Gas Research Institute*; Report for Gas Research Institute and U.S. Department of Energy; Energy & Environmental Research Center: Grand Forks, ND, Dec 1997.

JOHN RUBY
Project Manager
Nexant Inc.
101 Second Street, 11th Floor, San Francisco, CA 94105-3672
Phone: (415) 369-1000; Fax: (415) 981-9744; E-Mail: johnruby@attbi.com

Principal Areas of Expertise
Mr. Ruby has extensive experience in project management, engineering, and economic and financial evaluations for advanced and commercial energy technologies. He is currently leading GHG projects with several commercial clients. Mr. Ruby has extensive experience with conventional fuel sources, assisting private and public clients to develop cleaner, lower-emitting power generation systems.

Qualifications
M.B.A., Golden Gate University; M.S., Applied Earth Sciences, Stanford University; B.S., Mineral Processing, Stanford University.

Professional Experience
Project Manager, Zero Emission Coal Alliance (ZECA). Mr. Ruby is the project manager for work with the Zero Emission Coal Alliance, a group of roughly 20 companies and government agencies from the United States, Canada, Australia, and Germany. He and his team have prepared technical and business plans to assist ZECA with the research, development, and commercialization of a process to produce hydrogen and electric power from coal with zero atmospheric emissions. CO_2 is sequestered using a new process that is still under development by the U.S. Department of Energy and the National Laboratories. The business plan provides ZECA with Nexant's ideas and recommendations for pathways to fund, organize, and install a pilot plant to demonstrate the ZECA technology in about five years. Mr. Ruby is currently assisting ZECA Corporation with planning, fund-raising, and other efforts to advance the design and installation of a pilot plant.

Advanced Coal Combustion. Mr. Ruby successfully completed Nexant's advanced coal combustion work with United Technologies Research Center and the U.S. Department of Energy. He and his project team designed highly efficient and environmentally clean coal-based power generation systems. Emissions are 1/10 of new source performance standards. The project included an in-depth assessment of CO_2 separation and capture for the coal flue gas.

Other Projects. Mr. Ruby was a member of Bechtel Technology and Consulting, where he designed a suite of performance simulation models for the Canadian Electrical Association. He also managed their project to evaluate and compare technical and economic features of more than 60 fossil fuel (coal, gas, and oil) power generation technologies. The performance models were built with commercially available spreadsheet software and have been extensively updated and used in-house and by new clients. Mr. Ruby managed a 2-year project for Westinghouse, the Electric Power Research Institute, and a consortium of Japanese clients in which he assisted with designs and cost estimates for three solid oxide fuel cell power plants. He also performed an assessment of hydrogen energy systems for another Japanese client. The report evaluates hydrogen production using solid oxide electrolysis (SOE) and conventional water electrolysis

hydrogen processes. In addition, he worked with Westinghouse to develop megawatt-size fuel cell demonstration projects with U.S. and Japanese utilities.

Mr. Ruby is the author of more than 30 publications and the recipient of three Bechtel Outstanding Technical Paper awards.

Relevant Publications

- Zero Emission Coal Technologies, A Prudent Man Approach to North American Energy Security. Presented at the 27th International Technical Conference on Coal Utilization and Fuel Systems, March 2002.

- Zero Emission Coal Alliance Project Conceptual Design and Economics. Presented at the 26th International Technical Conference on Coal Utilization and Fuel Systems, March 2001.

- Assessment of Carbon Dioxide Separation Processes for High Performance Power Systems (HIPPS). Presented at GlobeEx 2000, July 2000.

- High Performance Power Systems (HIPPS) – Opportunities and Options for the Coal-Fired Power Plant Market. Presented at the Joint U.S. Department of Energy–Korean Workshop on Energy and the Environment, Sept 1999.

- High Performance Power Systems (HIPPS) – Coal-Based Repowering for the 21th Century. Presented at the ASME International Joint Power Generation Conference, 1999.

- Greenhouse Gas Reduction Through the Use of High Performance Power Systems (HIPPS). Presented at the ASME International Joint Power Generation Conference, Nov 1997.

DR. EVERETT A. SONDREAL
Principal Research Advisor
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax: (701) 777-5181; E-Mail: esondreal@undeerc.org

Principal Areas of Expertise

- Analysis of energy and environmental policy and strategic planning relating to resource assessment, energy production, price, technology, efficiency, and environmental impact/control.

- Planning of multiproject research activities involving resource properties, beneficiation, combustion, gasification, liquefaction, emissions control, and waste reuse or disposal.

- Process monitoring during plant construction, including assigned U.S. Department of Energy (DOE) responsibility for monitoring environmental control processes during construction of the Great Plains Coal Gasification Plant synfuels project.

- Technical liaison with industry and government agencies in the United States and overseas in Australia, Japan, Korea, Poland, Hungary, the Czech Republic, and Bulgaria.

- Knowledge of engineering and mathematical methods for process modeling and optimization.

Qualifications

Ph.D., Chemical Engineering, University of Michigan, 1972; M.S., Chemical Engineering, UND, 1962; B.S., Chemical Engineering, UND, 1957.

Professional Experience

1988–Present: Principal Research Advisor, EERC, UND.

1984–1991: President, Coal Energy Technology Consultants, Inc. (CETC), Grand Forks, ND. Provided consulting services on fuel properties and technologies.

1980–1983: Director, Grand Forks Energy Technology Center (GFETC) and Grand Forks Project Office, Grand Forks, ND (Lead Laboratory for Low-Rank Coal Applications, DOE). Responsible for $9–$12 million annual R&D budget and performance of research by 150 government and contractor employees on-site and research contractors off-site. Projects included work on coal properties, preparation, combustion, gasification, liquefaction, and environmental control. Directed DOE process monitoring during construction of the Great Plains Gasification Plant.

1962–1980: Deputy Director (1978–1980), Research Supervisor, and Research Engineer, GFETC. Directed and performed R&D on mine sampling and analysis of variability, storage, and spontaneous heating; utility/pilot-scale combustion tests; flue gas scrubbing; electrostatic precipitation; ash fusibility; coal liquefaction; and treatment of wastewater from coal gasification.

1960: Development Engineer, DuPont, Clinton, IA.
1957–1959: Nuclear Research Officer, U.S. Air Force, Sacramento, CA, and Fairbanks, AK.

Achievements and Awards

- EERC Energy Champion Award, 1995
- DOE Exceptional Service and Superior Achievement Awards, 1982 and 1983
- Cochair, DOE/UND Lignite Symposium, 1981 and 1983
- U.S. Patent No. 154,351, Continuous Liquefaction, 1982
- Member, Sigma Xi and Sigma Tau Professional Fraternities
- Outstanding Graduate Student, Chemical Engineering, University of Michigan, 1971
- U.S. Bureau of Mines Graduate Training Award, 1969
- Bureau of Mines Fellow, University of Michigan, 1970–1972; UND, 1960–1962
- Valedictorian and Distinguished Military Graduate, UND, 1957

Relevant Publications

- Pavlish, J.P.; Sondreal, E.A.; Mann, M.D.; Olson, E.S.; Galbreath, K.C.; Laudal, D.L.; Benson, S.A. A Status Review of Mercury Control Options for Coal-Fired Power Plants. Submitted to Special Mercury Issue of *Fuel Process. Technol*. **2002**.

- Laudal, D.L.; Pavlish, J.H.;Galbreath, K.C.; Thompson, J.S.; Weber, G.F.; Sondreal, E.A. *Pilot-Scale Evaluation of the Impact of Selective Catalytic Reduction for NO_x on Mercury Speciation*; Final Report for U.S. Environmental Protection Agency Cooperative Agreement No. R-828323091; EERC Publication 2001-EERC-12-03; Energy & Environmental Research Center: Grand Forks, ND, Dec 2001.

- Sondreal, E.A.; Benson, S.A.; Hurley, J.P.; Mann, M.D.; Pavlish, J.H.; Swanson, M.L.; Weber, G.F.; Zygarlicke, C.J. Review of Advances in Combustion Technology and Biomass Firing. *Fuel Process. Technol.* **2001**, 71 (1–3), 7-38.

- Sondreal, E.A.; Jones, M.L.; Groenewold, G.H. Tides and Trends in the World's Electric Power Industry. *Electricity J.* **2001**, *14* (1), 61–79.

- Sondreal, E.A.; Benson, S.A.; Pavlish, J.H. Status of Research on Air Quality: Mercury, Trace Elements, and Particulate Matter. In *Air Quality: Mercury, Trace Elements, and Particulate Matter*, Special Issue of *Fuel Process. Technol.* **2000**, *65–66*, 5–19.

- Sondreal, E.A.; Benson, S.A.; Hurley, J.P.; Mann, M.D.; Pavlish, J.H.; Swanson, M.L.; Weber, G.F.; Zygarlicke, C.J. Review of Advances in Combustion Technology and Biomass Cofiring. Presented at the Coal Technology and Utilization Conference, Ankara, Turkey, April 14–15, 2000.

- Benson, S.A.; Sondreal, E.A. Impact of Low-Rank Coal Properties on Advanced Power Systems. In *Ash Chemistry: Phase Relationships in Ashes,* Special Issue of *Fuel Process. Technol.* **1998**, *56* (1–2), 129–142.

- Sondreal, E.A. *White Paper: Policy Assessment on Climate Change*; Energy & Environmental Research Center: Grand Forks, ND, Nov 1997.

- Benson, S.A.; Sondreal, E.A.; Hurley, J.P. Status of Coal Ash Behavior Research. In *Ash Chemistry in Fossil Fuel Processes*, Special Issue of *Fuel Process. Technol.* **1995**, *44* (1–3), 1–12.

- Hetland, M.D.; Sondreal, E.A.; Olson, E.S.; Rindt, J.R. Overview of Low-Rank Coal Conversion to Liquid Fuels. In *Proceedings of the 12th International Pittsburgh Coal Conference*; Pittsburgh, PA, Sept 11–15, 1995; S.-H., Chiang, Ed.; 1995; pp 1029–1034.

- Benson, S.A.; Sondreal, E.A.; Hurley, J.P. Status of Coal Ash Behavior Research. *Prepr. Pap.—Am. Chem. Soc., Div. Fuel Chem.* **1994**, *39* (1), 81–88.

- Sondreal, E.A.; Jones, M.L.; Hurley, J.P.; Benson, S.A.; Willson, W.G. Cradle-to-Grave Approach— Impact of Fuel Properties on Advanced Power Systems. In *Proceedings of the 17th Biennial Low-Rank Fuels Symposium*; St. Louis, MO, May 10–13, 1993; Energy & Environmental Research Center: Grand Forks, ND, 1993; pp 127–159.

- Sondreal, E.A. Clean Utilization of Low-Rank Coals for Low-Cost Power Generation. Presented at the International Conference on the Clean and Efficient Use of Coal, Budapest, Hungary, Feb 24–27, 1992.

- Sondreal, E.A. Status of Conversion Technology for Fort Union Lignites: A Survey. In *Geology and Utilization of Fort Union Lignites*; Finkelman, R.B.; Tewalt, S.J.; Daly, D.J., Eds.; Environmental and Coal Associates: Reston, VA, 1992; pp 223–259.

- Sondreal, E.A.; Willson, W.G. Use of Low-Rank Coals for Clean Low-Cost Power Generation. Presented at the 9th U.S.–Korea Workshop on Coal Utilization Technology, San Francisco, CA, Oct 18–20, 1992.

- Hauserman, W.B.; Sondreal E.A.; Willson, W.G.; Timpe, R.C.; Cisney, S.J. *Recommendations for Disposable Gasification Catalysts to Optimize Integrated Gasifier/Fuel Cell Systems*; Report for Energy Research Corporation and Fluor-Daniel Inc.; Energy & Environmental Research Center: Grand Forks, ND, Jan 1991.

- Timpe, R.C.; Sears, R.E.; Willson, W.G.; Sondreal, E.A. *Hydrogen Production from Low-Rank Coals: Topical Report on Char Properties and Reactivity*; Topical Report for U.S. Department of Energy Contract No. DE-FC21-86MC10637; Energy & Environmental Research Center: Grand Forks, ND, May 1989.

JAMES A. SORENSEN
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5000; Fax: (701) 777-5181; E-Mail: jsorensen@undeerc.org

Principal Areas of Expertise
Contaminant hydrogeology, soil and groundwater remediation, hydrogeologic data reduction and interpretation, and environmental issues related to the oil and gas industry.

Qualifications
B.S., Geology, UND, 1991; postgraduate course work in Hydrogeology, Advanced Geomorphology, Groundwater Monitoring and Remediation, Geochemistry, and Contaminant Hydrogeology, 1993–1995; 40-hour OSHA Training for Hazardous Waste Site Personnel, 1998 (refresher course, 1999).

Professional Experience
1999–Present: Senior Research Manager, EERC, UND. Currently serves as manager and coprincipal investigator for several research programs, including a 3-year, $1.2 million program focused on the subsurface environmental fate and remediation of natural gas-processing wastes. 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, interacting with clients and industrial contacts, and proposal writing and presentation.

1997–1999: Program Manager, EERC, UND. Managed projects on topics that included treatment of produced water from gas production activities, environmental fate of mercury, and gas methane hydrates. He cochaired the Workshop on Environmental Issues Related to Gas Sweetening Alkanolamines, sponsored by Gas Research Institute and the U.S. Department of Energy, in Calgary, Alberta, Canada, April 28–29, 1998.

1993–1997: Geologist, EERC, UND. Conducted a variety of field-based hydrogeologic investigations throughout the United States and Canada. Activities were primarily focused on evaluating the subsurface transport and fate of mercury associated with natural gas production sites. Other research topics included the subsurface transport and fate of natural gas processing wastes and agricultural chemicals.

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

Professional Memberships
- Society of Petroleum Engineers

Relevant Publications

- Gallagher, J.R., and Sorensen, J.A., 2001, Biological treatment of amine wastes from the gas industry: in In Situ and On-Site Bioremediation: the 6th International Symposium, San Diego, California, June 4–7, 2001.

- Kurz, M.D., and Sorensen, J.A., 2001, An overview of environmental issues related to coalbed methane development in Montana: 2001 International Petroleum Environmental Conference (IPEC*)*, Houston, TX, Nov 6–9, 2001, Proceedings.

- Sorensen, J.A., Gallagher, J.R., and Harju, J.A., 2000, Subsurface environmental issues at natural gas dehydration sites– biodegradability of glycol-related wastes, *in* 7th Annual International Petroleum Environmental Conference, Albuquerque, New Mexico, November 6–8, 2000.

- Sorensen, J.A., Gallagher, J.R., Chollak, D., and Harju, J.A., 1999, Remediation strategies for soils contaminated with amine-based gas sweetening wastes, Society of Petroleum Engineers/ Environmental Protection Agency 1999 Exploration and Production Environmental Conference, Austin, Texas, March 1–3, 1999.

- Sorensen, J.A., Aulich, T.R., Hawthorne, S.B., Gallagher, J.R., Thompson, J.S., and Hoffman, R.J., 1998, Amine-based gas-sweetening fluids—waste stream characterization and subsurface transport and fate: Topical report for Gas Research Institute Contract No. 5090-253-1930 and U.S. Department of Energy Contract No. DE-FC21-93MC30098, GRI-98/0388, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

- Stoa, R.S., Peck, W.D., and Sorensen, J.A., 1997, Development of a natural settings geographic information system database for Gas Research Institute: Report for Gas Research Institute and U.S. Department of Energy, Grand Forks, North Dakota, Energy & Environmental Research Center, December 1997.

- Stoa, R.S., Bassingthwaite, S.A., and Sorensen, J.A., 1995, PCs ease geographic oil and gas data base visualization: Oil & Gas Journal, September 25, p. 79–83.

EDWARD N. STEADMAN
Senior Research Advisor
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (814) 476-7477; Fax: (701) 777-5181; E-Mail: esteadman@undeerc.org

Principal Areas of Expertise
Environmental management, watersheds, sustainable development, chemical transformations during coal combustion, and materials science.

Qualifications
M.A., Geology, Summa Cum Laude, UND, 1985; B.S., Geology, Cum Laude, State University of Pennsylvania-Edinboro, 1982.

Professional Experience
2003–Present: Senior Research Advisor, EERC, UND. Responsibilities include development, marketing, management, and dissemination of market-oriented research; development of programs focused on the environmental and health effects of power and natural resource production, contaminant cleanup, water management, and analytical techniques; publication and presentation of results; client interactions; and advising EERC staff.

1994–2002: Associate Director for Research, EERC, UND. Responsibilities included developing and administering environmental programs involving water management and contamination cleanup and building industry–government–academic teams to carry out research, development, demonstration, and commercialization of environmental products and technologies.

1988–1994: Research Manager, Fuels and Materials Science, EERC, UND. Responsibilities included research project management and coordination of research activities. He was responsible for inorganic analytical methods development and preparation and presentation of research publications, reports, and proposals.

1987–1988: Instructor, Valley City State University, Valley City, North Dakota. Responsibilities included teaching earth science, physical and historical geology, geomorphology, astronomy, and geography. He also supervised work-study students.

1986–1987: Research Associate, Energy and Mineral Research Center, UND. Responsibilities included conducting research into the chemical and physical mechanisms of coal combustion and the characterization of coal and coal ash. He was responsible for experimental design as well as preparation of research publications, reports, and proposals.

1985–1986: Associated Western Universities Postgraduate Fellow. Responsibilities included writing research proposals and reports as well as mine sampling and chemical analysis of coals and related strata throughout the western United States.

Relevant Publications
- Groenewold, G.H.; Steadman, E.N.; Moe, T.A. The Red River Water Management Consortium – A Partnership for Developing Effective Water Management Strategies.

Presented at the Land, Water and People: Partners for a Sustainable Future 18th Annual Red River Basin Land and Water International Summit Conference, Grand Forks, ND, Jan 16–18, 2001.

- Solc, J.; Steadman, E.N., *Integrated Chemical Reaction Kinetics in Contaminant Transport Model, Phase I*. Final Report for U.S. Department of Energy Environmental Management Contract No. DE-FC21-94MC31388; EERC Publication 2000-EERC-03-02; Energy & Environmental Research Center: Grand Forks, ND, March 2000.

- Solc, J.; Boysen, J.E.; Steadman, E.N. A Feasibility Study for Underground Coal Gasification at Krabi Mine, Thailand. In *Proceedings of the 15th Annual International Pittsburgh Coal Conference*; Pittsburgh, PA, Sept 14–18, 1998.

- Benson, S.A.; Steadman, E.N.; Zygarlicke, C.J.; Erickson, T.A. Ash Formation, Deposition, Corrosion, and Erosion in Conventional Boilers. In *Applications of Advanced Technology to Ash-Related Problems in Boilers*; Baxter, L.; DeSollar, R., Eds.; Plenum Press: New York, 1996; pp 1–15.

- *Trace Element Transformations in Coal Fired Power Systems*, Special Issue of *Fuel Process. Technol.*; Benson, S.A.; Steadman, E.N.; Mehta, A.; Schmidt, C., Eds.; Elsevier Science Publishers: Amsterdam, Aug 1994; Vol. 39, Nos. 1–3, 492 p.

- Jones, M.L.; Kalmanovitch, D.P.; Steadman, E.N.; Zygarlicke, C.J.; Benson, S.A. Application of SEM Techniques to the Characterization of Coal and Coal Ash Products. In *Advances in Coal Spectroscopy*; Plenum Publishing Co.: New York, 1992; pp 1–27.

- Kroeger, T.J.; Steadman, E.S. Review of Palynological Research on Paleocene Rocks of the Williston Basin. In *Geology and Utilization of Fort Union Lignites*; Finkelman, R.B.; Tewalt, S.J.; Daly, D.J., Eds.; Environmental and Coal Associates: Reston, VA, 1992; pp 76–85.

- Luther, M.R.; Steadman, E.N.; Hills, L.V. Depositional Setting and Preservation of a Megaspore Flora from the Mission Canyon Formation (Mississippian), Bottineau County, North Dakota. In *Proceedings of the 5th International Williston Basin Symposium*; Carlson, C.G.; Christopher, J.E., Eds.; 1987; pp 107–116.

APPENDIX D

DETAILED BUDGET AND BUDGET NOTES

SUMMARY BUDGET - ALL YEARS

PLAINS CO2 REDUCTION PARTNERSHIP
DOE/NDIC/MULTI-CLIENT
PROPOSED START DATE: 11/01/03
EERC PROPOSAL #2003-0103

CATEGORY		TOTAL HRS	TOTAL $COST	NDIC SHARE HRS	NDIC SHARE $COST	UTILITIES SHARE HRS	UTILITIES SHARE $COST	DOE SHARE HRS	DOE SHARE $COST
TOTAL DIRECT LABOR		17,333	$ 602,738	2,505	$ 90,399	1,255	$ 45,301	13,573	$ 467,038
FRINGE BENEFITS - % OF DIRECT LABOR	54%		$ 325,479		$ 48,815		$ 24,463		$ 252,201
TOTAL LABOR			$ 928,217		$ 139,214		$ 69,764		$ 719,239
OTHER DIRECT COSTS									
TRAVEL			$ 65,258		$ 11,705		$ 5,695		$ 47,858
COMMUNICATION - PHONES & POSTAGE			$ 3,300		$ 533		$ 267		$ 2,500
DATA PROCESSING - SOFTWARE			$ 2,000		$ -		$ -		$ 2,000
OFFICE (PROJECT SPECIFIC SUPPLIES)			$ 8,400		$ 2,394		$ 1,196		$ 4,810
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)			$ 5,500		$ -		$ -		$ 5,500
FEES (AND SUBCONTRACTS)			$ 373,175		$ -		$ -		$ 373,175
TOTAL OTHER DIRECT COST			$ 457,633		$ 14,632		$ 7,158		$ 435,843
TOTAL DIRECT COST			$ 1,385,850		$ 153,846		$ 76,922		$ 1,155,082
FACILITIES & ADMIN. RATE - % OF MTDC		VAR	$ 560,764	56%	$ 86,154	56%	$ 43,078	47.7%	$ 431,532
TOTAL EERC COST			$ 1,946,614		$ 240,000		$ 120,000		$ 1,586,614
IN-KIND COST SHARE									
NDSU			$ 34,950						
DAKOTA GASIFICATION			$ 700,000						
PRAIRIE PUBLIC TV			$ 66,575						
TOTAL IN-KIND COST SHARE			$ 801,525						
TOTAL PROJECT COST			$ 2,748,139						

NOTE: Due to limitations within the University's accounting system, the system does not provide for accumulating and reporting expenses at the Detailed Budget level. The Summary Budget is presented for the purpose of how we propose, account, and report expenses. The Detailed Budget is presented to assist in the evaluation of the proposal.

DETAILED BUDGET - ALL YEARS

PLAINS CO2 REDUCTION PARTNERSHIP
DOE/NDIC/MULTI-CLIENT
PROPOSED START DATE: 11/01/03
EERC PROPOSAL #2003-0103

LABOR	LABOR CATEGORY	HOURLY RATE	YEAR ONE TOTAL HRS	YEAR ONE TOTAL $COST	YEAR TWO TOTAL HRS	YEAR TWO TOTAL $COST	ALL YEARS TOTAL HRS	ALL YEARS TOTAL $COST	NDIC SHARE HRS	NDIC SHARE $COST	UTILITIES SHARE HRS	UTILITIES SHARE $COST	DOE SHARE HRS	DOE SHARE $COST
ERICKSON, T.	PROJECT MANAGER	$ 48.73	720	$ 35,085	760	$ 37,034	1,480	$ 72,119	346	$ 16,860	174	$ 8,480	960	$ 46,779
HARJU, J.	PRINCIPAL INVESTIGATOR	$ 48.08	280	$ 13,463	220	$ 10,578	500	$ 24,041	200	$ 9,616	100	$ 4,808	200	$ 9,617
DALY, D.	PRINCIPAL INVESTIGATOR	$ 28.35	370	$ 10,490	510	$ 14,459	880	$ 24,949	333	$ 9,441	167	$ 4,734	380	$ 10,774
SORENSEN, J.	RESEARCH SCIENTIST/ENGINEER	$ 36.60	800	$ 29,280	440	$ 16,104	1,240	$ 45,384	333	$ 12,188	167	$ 6,112	740	$ 27,084
HAWTHORNE, S.	RESEARCH SCIENTIST/ENGINEER	$ 49.13	100	$ 4,913	25	$ 1,228	125	$ 6,141	-	$ -	-	$ -	125	$ 6,141
NELSON, C.	RESEARCH SCIENTIST/ENGINEER	$ 34.95	100	$ 3,496	60	$ 2,098	160	$ 5,594	-	$ -	-	$ -	160	$ 5,594
EVANS, J.	RESEARCH SCIENTIST/ENGINEER	$ 34.95	100	$ 3,496	100	$ 3,496	200	$ 6,992	-	$ -	-	$ -	200	$ 6,992
LAUDAL, D.	RESEARCH SCIENTIST/ENGINEER	$ 43.06	520	$ 22,391	200	$ 8,612	720	$ 31,003	-	$ -	-	$ -	720	$ 31,003
O'LEARY, E.	RESEARCH SCIENTIST/ENGINEER	$ 35.85	300	$ 10,755	220	$ 7,887	520	$ 18,642	-	$ -	-	$ -	520	$ 18,642
WEBER, G.	RESEARCH SCIENTIST/ENGINEER	$ 48.71	220	$ 10,717	300	$ 14,613	520	$ 25,330	-	$ -	-	$ -	520	$ 25,330
MUSICH, M.	RESEARCH SCIENTIST/ENGINEER	$ 30.20	600	$ 18,120	600	$ 18,120	1,200	$ 36,240	-	$ -	-	$ -	1,200	$ 36,240
----------	SENIOR MANAGEMENT	$ 48.20	234	$ 11,279	187	$ 9,013	421	$ 20,292	-	$ -	-	$ -	421	$ 20,292
----------	RESEARCH SCIENTIST/ENGINEER	$ 26.94	4,078	$ 109,861	3,838	$ 103,396	7,916	$ 213,257	1,293	$ 34,833	647	$ 17,430	5,976	$ 160,994
----------	RESEARCH TECHNICIAN	$ 18.42	389	$ 7,165	312	$ 5,747	701	$ 12,912	-	$ -	-	$ -	701	$ 12,912
----------	TECHNICAL SUPPORT SERVICES	$ 14.62	400	$ 5,848	350	$ 5,117	750	$ 10,965	-	$ -	-	$ -	750	$ 10,965
			9,211	$ 296,359	8,122	$ 257,502	17,333	$ 553,861	2,505	$ 82,938	1,255	$ 41,564	13,573	$ 429,359
ESCALATION ABOVE CURRENT BASE		VAR		$ 19,264		$ 29,613		$ 48,877		$ 7,461		$ 3,737		$ 37,679
TOTAL DIRECT LABOR				$ 315,623		$ 287,115		$ 602,738		$ 90,399		$ 45,301		$ 467,038
FRINGE BENEFITS - % OF DIRECT LABOR		54%		$ 170,437		$ 155,042		$ 325,479		$ 48,815		$ 24,463		$ 252,201
TOTAL LABOR				$ 486,060		$ 442,157		$ 928,217		$ 139,214		$ 69,764		$ 719,239
OTHER DIRECT COSTS														
TRAVEL				$ 35,316		$ 29,942		$ 65,258		$ 11,705		$ 5,695		$ 47,858
COMMUNICATION - PHONES & POSTAGE				$ 1,650		$ 1,650		$ 3,300		$ 533		$ 267		$ 2,500
DATA PROCESSING - SOFTWARE				$ 2,000		$ -		$ 2,000		$ -		$ -		$ 2,000
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 4,200		$ 4,200		$ 8,400		$ 2,394		$ 1,196		$ 4,810
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$ 2,750		$ 2,750		$ 5,500		$ -		$ -		$ 5,500
GRAPHICS SUPPORT				$ 5,815		$ 6,957		$ 12,772		$ -		$ -		$ 12,772
SUBCONTRACT - NDSU				$ 82,853		$ 56,950		$ 139,803		$ -		$ -		$ 139,803
SUBCONTRACT - UNSPECIFIED				$ 15,000		$ 15,000		$ 30,000		$ -		$ -		$ 30,000
SUBCONTRACT - DAKOTA GASIFICATION				$ 6,042		$ 3,958		$ 10,000		$ -		$ -		$ 10,000
SUBCONTRACT - NEXANT- BECHTEL				$ 42,240		$ 63,360		$ 105,600		$ -		$ -		$ 105,600
SUBCONTRACT - PRAIRIE PUBLIC TV				$ 50,000		$ 25,000		$ 75,000		$ -		$ -		$ 75,000
TOTAL OTHER DIRECT COST				$ 247,866		$ 209,767		$ 457,633		$ 14,632		$ 7,158		$ 435,843
TOTAL DIRECT COST				$ 733,926		$ 651,924		$ 1,385,850		$ 153,846		$ 76,922		$ 1,155,082
FACILITIES & ADMIN. RATE - % OF MTDC		VAR		$ 311,916		$ 248,848		$ 560,764	56%	$ 86,154	56%	$ 43,078	47.7%	$ 431,532
TOTAL EERC COST				$ 1,045,842		$ 900,772		$ 1,946,614		$ 240,000		$ 120,000		$ 1,586,614
IN-KIND COST SHARE														
NDSU				$ 34,950		$ -		$ 34,950						
DAKOTA GASIFICATION				$ 315,000		$ 385,000		$ 700,000						
PRAIRIE PUBLIC TV				$ 45,100		$ 21,475		$ 66,575						
TOTAL IN-KIND COST SHARE				$ 395,050		$ 406,475		$ 801,525						
TOTAL PROJECT COST				$ 1,440,892		$ 1,307,247		$ 2,748,139						

DETAILED BUDGET - YEAR ONE

PLAINS CO2 REDUCTION PARTNERSHIP
DOE/NDIC/MULTI-CLIENT
PROPOSED START DATE: 11/01/03
EERC PROPOSAL #2003-0103

LABOR	LABOR CATEGORY	HOURLY RATE	TOTAL YEAR ONE HRS	TOTAL YEAR ONE $COST	COST SHARE HRS	COST SHARE $COST	DOE SHARE HRS	DOE SHARE $COST
ERICKSON, T.	PROJECT MANAGER	$ 48.73	720	$ 35,085	260	$ 12,670	460	$ 22,415
HARJU, J.	PRINCIPAL INVESTIGATOR	$ 48.08	280	$ 13,463	180	$ 8,654	100	$ 4,809
DALY, D.	PRINCIPAL INVESTIGATOR	$ 28.35	370	$ 10,490	180	$ 5,103	190	$ 5,387
SORENSEN, J.	RESEARCH SCIENTIST/ENGINEER	$ 36.60	800	$ 29,280	320	$ 11,712	480	$ 17,568
HAWTHORNE, S.	RESEARCH SCIENTIST/ENGINEER	$ 49.13	100	$ 4,913	-	$ -	100	$ 4,913
NELSON, C.	RESEARCH SCIENTIST/ENGINEER	$ 34.95	100	$ 3,496	-	$ -	100	$ 3,496
EVANS, J.	RESEARCH SCIENTIST/ENGINEER	$ 34.95	100	$ 3,496	-	$ -	100	$ 3,496
LAUDAL, D.	RESEARCH SCIENTIST/ENGINEER	$ 43.06	520	$ 22,391	-	$ -	520	$ 22,391
O'LEARY, E.	RESEARCH SCIENTIST/ENGINEER	$ 35.85	300	$ 10,755	-	$ -	300	$ 10,755
WEBER, G.	RESEARCH SCIENTIST/ENGINEER	$ 48.71	220	$ 10,717	-	$ -	220	$ 10,717
MUSICH, M.	RESEARCH SCIENTIST/ENGINEER	$ 30.20	600	$ 18,120	-	$ -	600	$ 18,120
----------	SENIOR MANAGEMENT	$ 48.20	234	$ 11,279	-	$ -	234	$ 11,279
----------	RESEARCH SCIENTIST/ENGINEER	$ 26.94	4,078	$ 109,861	900	$ 24,246	3,178	$ 85,615
----------	RESEARCH TECHNICIAN	$ 18.42	389	$ 7,165	-	$ -	389	$ 7,165
----------	TECHNICAL SUPPORT SERVICES	$ 14.62	400	$ 5,848	-	$ -	400	$ 5,848
			9,211	$ 296,359	1,840	$ 62,385	7,371	$ 233,974
ESCALATION ABOVE CURRENT BASE		6.5%		$ 19,264		$ 4,055		$ 15,209
TOTAL DIRECT LABOR				$ 315,623		$ 66,440		$ 249,183
FRINGE BENEFITS - % OF DIRECT LABOR		54%		$ 170,437		$ 35,878		$ 134,559
TOTAL LABOR				$ 486,060		$ 102,318		$ 383,742
OTHER DIRECT COSTS								
TRAVEL				$ 35,316		$ 10,000		$ 25,316
COMMUNICATION - PHONES & POSTAGE				$ 1,650		$ 800		$ 850
DATA PROCESSING - SOFTWARE				$ 2,000		$ -		$ 2,000
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 4,200		$ 2,266		$ 1,934
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$ 2,750		$ -		$ 2,750
GRAPHICS SUPPORT				$ 5,815		$ -		$ 5,815
SUBCONTRACT - NDSU				$ 82,853		$ -		$ 82,853
SUBCONTRACT - UNSPECIFIED				$ 15,000		$ -		$ 15,000
SUBCONTRACT - DAKOTA GASIFICATION				$ 6,042		$ -		$ 6,042
SUBCONTRACT - NEXANT- BECHTEL				$ 42,240		$ -		$ 42,240
SUBCONTRACT - PRAIRIE PUBLIC TV				$ 50,000		$ -		$ 50,000
TOTAL OTHER DIRECT COST				$ 247,866		$ 13,066		$ 234,800
TOTAL DIRECT COST				$ 733,926		$ 115,384		$ 618,542
FACILITIES & ADMIN. RATE - % OF MTDC		VAR		$ 311,916	56%	$ 64,616	47.7%	$ 247,300
TOTAL EERC COST				$ 1,045,842		$ 180,000		$ 865,842
IN-KIND COST SHARE								
NDSU				$ 34,950		$ 34,950		
DAKOTA GASIFICATION				$ 315,000		$ 315,000		
PRAIRIE PUBLIC TV				$ 45,100		$ 45,100		
TOTAL IN-KIND COST SHARE				$ 395,050		$ 395,050		
TOTAL PROJECT COST				$ 1,440,892		$ 575,050		

DETAILED BUDGET - YEAR TWO

PLAINS CO2 REDUCTION PARTNERSHIP
DOE/NDIC/MULTI-CLIENT
PROPOSED START DATE: 11/01/03
EERC PROPOSAL #2003-0103

LABOR	LABOR CATEGORY	HOURLY RATE	TOTAL YEAR TWO HRS	TOTAL YEAR TWO $COST	COST SHARE HRS	COST SHARE $COST	DOE SHARE HRS	DOE SHARE $COST
ERICKSON, T.	PROJECT MANAGER	$ 48.73	760	$ 37,034	260	$ 12,670	500	$ 24,364
HARJU, J.	PRINCIPAL INVESTIGATOR	$ 48.08	220	$ 10,578	120	$ 5,770	100	$ 4,808
DALY, D.	PRINCIPAL INVESTIGATOR	$ 28.35	510	$ 14,459	320	$ 9,072	190	$ 5,387
SORENSEN, J.	RESEARCH SCIENTIST/ENGINEER	$ 36.60	440	$ 16,104	180	$ 6,588	260	$ 9,516
HAWTHORNE, S.	RESEARCH SCIENTIST/ENGINEER	$ 49.13	25	$ 1,228	-	$ -	25	$ 1,228
NELSON, C.	RESEARCH SCIENTIST/ENGINEER	$ 34.95	60	$ 2,098	-	$ -	60	$ 2,098
EVANS, J.	RESEARCH SCIENTIST/ENGINEER	$ 34.95	100	$ 3,496	-	$ -	100	$ 3,496
LAUDAL, D.	RESEARCH SCIENTIST/ENGINEER	$ 43.06	200	$ 8,612	-	$ -	200	$ 8,612
O'LEARY, E.	RESEARCH SCIENTIST/ENGINEER	$ 35.85	220	$ 7,887	-	$ -	220	$ 7,887
WEBER, G.	RESEARCH SCIENTIST/ENGINEER	$ 48.71	300	$ 14,613	-	$ -	300	$ 14,613
MUSICH, M.	RESEARCH SCIENTIST/ENGINEER	$ 30.20	600	$ 18,120	-	$ -	600	$ 18,120
----------	SENIOR MANAGEMENT	$ 48.20	187	$ 9,013	-	$ -	187	$ 9,013
----------	RESEARCH SCIENTIST/ENGINEER	$ 26.94	3,838	$ 103,396	1,040	$ 28,017	2,798	$ 75,379
----------	RESEARCH TECHNICIAN	$ 18.42	312	$ 5,747	-	$ -	312	$ 5,747
----------	TECHNICAL SUPPORT SERVICES	$ 14.62	350	$ 5,117	-	$ -	350	$ 5,117
			8,122	$ 257,502	1,920	$ 62,117	6,202	$ 195,385
ESCALATION ABOVE CURRENT BASE		11.5%		$ 29,613		$ 7,143		$ 22,470
TOTAL DIRECT LABOR				$ 287,115		$ 69,260		$ 217,855
FRINGE BENEFITS - % OF DIRECT LABOR		54%		$ 155,042		$ 37,400		$ 117,642
TOTAL LABOR				$ 442,157		$ 106,660		$ 335,497
OTHER DIRECT COSTS								
TRAVEL				$ 29,942		$ 7,400		$ 22,542
COMMUNICATION - PHONES & POSTAGE				$ 1,650		$ -		$ 1,650
DATA PROCESSING - SOFTWARE				$ -		$ -		$ -
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 4,200		$ 1,324		$ 2,876
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$ 2,750		$ -		$ 2,750
GRAPHICS SUPPORT				$ 6,957		$ -		$ 6,957
SUBCONTRACT - NDSU				$ 56,950		$ -		$ 56,950
SUBCONTRACT - UNSPECIFIED				$ 15,000		$ -		$ 15,000
SUBCONTRACT - DAKOTA GASIFICATION				$ 3,958		$ -		$ 3,958
SUBCONTRACT - NEXANT- BECHTEL				$ 63,360		$ -		$ 63,360
SUBCONTRACT - PRAIRIE PUBLIC TV				$ 25,000		$ -		$ 25,000
TOTAL OTHER DIRECT COST				$ 209,767		$ 8,724		$ 201,043
TOTAL DIRECT COST				$ 651,924		$ 115,384		$ 536,540
FACILITIES & ADMIN. RATE - % OF MTDC		VAR		$ 248,848	56%	$ 64,616	47.7%	$ 184,232
TOTAL EERC COST				$ 900,772		$ 180,000		$ 720,772
IN-KIND COST SHARE								
NDSU				$ -		$ -		
DAKOTA GASIFICATION				$ 385,000		$ 385,000		
PRAIRIE PUBLIC TV				$ 21,475		$ 21,475		
TOTAL IN-KIND COST SHARE				$ 406,475		$ 406,475		
TOTAL PROJECT COST				$ 1,307,247		$ 586,475		

DETAILED BUDGET - FEES

PLAINS CO2 REDUCTION PARTNERSHIP
EERC PROPOSAL #2003-0103

GRAPHICS SUPPORT	RATE	YEAR ONE #	YEAR ONE $COST	YEAR TWO #	YEAR TWO $COST	ALL YEARS #	ALL YEARS $COST
GRAPHICS (HOURLY)	$39	140	$ 5,460	160	$ 6,240	300	$ 11,700
SUBTOTAL			$ 5,460		$ 6,240		$ 11,700
ESCALATION		6.5%	$ 355	11.5%	$ 717	VAR	$ 1,072
TOTAL GRAPHICS SUPPORT			$ 5,815		$ 6,957		$ 12,772

DETAILED BUDGET - TRAVEL

PLAINS CO2 REDUCTION PARTNERSHIP
EERC PROPOSAL #2003-0103

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	AIRFARE	PER MILE	LODGING	PER DIEM	CAR RENTAL	REGIST.
PCORP Region - Air	$ 900	$ -	$ 100	$ 30	$ 50	
PCORP Region - Ground	$ -	$ 0.31	$ 50	$ 20	$ -	
Outside PCORP Region	$ 1,200	$ -	$ 125	$ 46	$ 50	$ 400
Morgantown, WV (via Pittsburgh, PA)	$ 1,060	$ -	$ 65	$ 38	$ 50	

PURPOSE/DESTINATION	NUMBER OF TRIPS	NUMBER OF PEOPLE	NUMBER OF MILES	NUMBER OF DAYS	AIRFARE	MILEAGE	LODGING	PER DIEM	CAR RENTAL	MISC.	REGIST.	TOTAL
TASK 1												
Stakeholder, partner meetings/PCORP Region - Air	2	2		3	$ 3,600	$ -	$ 800	$ 360	$ 300	$ 240	$ -	$ 5,300
Stakeholder, partner meetings/PCORP Region - Ground	1	2	600	3	$ -	$ 186	$ 200	$ 120	$ -	$ 60	$ -	$ 566
Conference or Presentation/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
Briefing/Morgantown, WV (Pittsburgh, PA)	1	2		3	$ 2,120	$ -	$ 260	$ 228	$ 150	$ 120	$ -	$ 2,878
Annual Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	2		3	$ 2,120	$ -	$ 260	$ 228	$ 150	$ 120	$ -	$ 2,878
TOTAL TASK 1 (YEAR ONE)												$ 13,820
TASK 2												
Stakeholder, partner meetings/PCORP Region - Air	2	1		3	$ 1,800	$ -	$ 400	$ 180	$ 300	$ 120	$ -	$ 2,800
Stakeholder, partner meetings/PCORP Region - Ground	1	1	600	3	$ -	$ 186	$ 100	$ 60	$ -	$ 30	$ -	$ 376
Conference or Presentation/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
TOTAL TASK 2 (YEAR ONE)												$ 5,374
TASK 3												
Stakeholder, partner meetings/PCORP Region - Air	2	1		3	$ 1,800	$ -	$ 400	$ 180	$ 300	$ 120	$ -	$ 2,800
Stakeholder, partner meetings/PCORP Region - Ground	1	1	600	3	$ -	$ 186	$ 100	$ 60	$ -	$ 30	$ -	$ 376
Conference or Presentation/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
TOTAL TASK 3 (YEAR ONE)												$ 5,374
TASK 4												
Stakeholder, partner meetings/PCORP Region - Air	2	1		3	$ 1,800	$ -	$ 400	$ 180	$ 300	$ 120	$ -	$ 2,800
Stakeholder, partner meetings/PCORP Region - Ground	1	1	600	3	$ -	$ 186	$ 100	$ 60	$ -	$ 30	$ -	$ 376
Conference or Meeting/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
TOTAL TASK 4 (YEAR ONE)												$ 5,374
TASK 5												
Stakeholder, partner meetings/PCORP Region - Air	2	1		3	$ 1,800	$ -	$ 400	$ 180	$ 300	$ 120	$ -	$ 2,800
Stakeholder, partner meetings/PCORP Region - Ground	1	1	600	3	$ -	$ 186	$ 100	$ 60	$ -	$ 30	$ -	$ 376
Conference or Meeting/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
TOTAL TASK 5 (YEAR ONE)												$ 5,374
TOTAL ESTIMATED TRAVEL -YEAR ONE												$ 35,316
TASK 1												
Stakeholder, partner meetings/PCORP Region - Air	2	2		3	$ 3,600	$ -	$ 800	$ 360	$ 300	$ 240	$ -	$ 5,300
Stakeholder, partner meetings/PCORP Region - Ground	1	2	600	3	$ -	$ 186	$ 200	$ 120	$ -	$ 60	$ -	$ 566
Conference or Meeting/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
Briefing/Morgantown, WV (Pittsburgh, PA)	1	2		3	$ 2,120	$ -	$ 260	$ 228	$ 150	$ 120	$ -	$ 2,878
Annual Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	2		3	$ 2,120	$ -	$ 260	$ 228	$ 150	$ 120	$ -	$ 2,878
TOTAL TASK 1 (YEAR TWO)												$ 13,820
TASK 2												
Stakeholder, partner meetings/PCORP Region - Air	2	1		3	$ 1,800	$ -	$ 400	$ 180	$ 300	$ 120	$ -	$ 2,800
Stakeholder, partner meetings/PCORP Region - Ground	1	1	600	3	$ -	$ 186	$ 100	$ 60	$ -	$ 30	$ -	$ 376
Conference or Meeting/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
TOTAL TASK 2 (YEAR TWO)												$ 5,374
TASK 3												
Stakeholder, partner meetings/PCORP Region - Air	2	1		3	$ 1,800	$ -	$ 400	$ 180	$ 300	$ 120	$ -	$ 2,800
Stakeholder, partner meetings/PCORP Region - Ground	1	1	600	3	$ -	$ 186	$ 100	$ 60	$ -	$ 30	$ -	$ 376
Conference or Meeting/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
TOTAL TASK 3 (YEAR TWO)												$ 5,374
TASK 5												
Stakeholder, partner meetings/PCORP Region - Air	2	1		3	$ 1,800	$ -	$ 400	$ 180	$ 300	$ 120	$ -	$ 2,800
Stakeholder, partner meetings/PCORP Region - Ground	1	1	600	3	$ -	$ 186	$ 100	$ 60	$ -	$ 30	$ -	$ 376
Conference or Meeting/Outside PCORP	1	1		3	$ 1,200	$ -	$ 250	$ 138	$ 150	$ 60	$ 400	$ 2,198
TOTAL TASK 5 (YEAR TWO)												$ 5,374
TOTAL ESTIMATED TRAVEL -YEAR TWO												$ 29,942
TOTAL ESTIMATED TRAVEL - ALL YEARS												$ 65,258

NOTE: THE TRAVEL OUTSIDE OF PCORP REGION MAY INCLUDE CONFERENCES AND/OR INDUSTRY MEETINGS, THEREFORE CONFERENCE REGISTRATION FEES HAVE BEEN BUDGETED

BUDGET NOTES

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

Background

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC receives no appropriated funding from the state of North Dakota and is funded through federal and nonfederal grants, contracts, or other agreements. Although the EERC is not affiliated with any one academic department, university academic faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, subcontracts) is for planning purposes only. The principal investigator may, as dictated by the needs of the work, reallocate the budget among approved items or use the funds for other items directly related to the project, subject only to staying within the total dollars authorized for the overall program. The budget prepared for this proposal is based on a specific start date; this start date is indicated at the top of the EERC budget or identified in the body of the proposal. Please be aware that any delay in the start of this project may result in an increase in the budget. Financial reporting will be at the total project level.

Salaries and Fringe Benefits

As an interdisciplinary, multiprogram, and multiproject research center, the EERC employs an administrative staff to provide required services for various direct and indirect support functions. Direct project salary estimates are based on the scope of work and prior experience on projects of similar scope. Technical and administrative salary charges are based on direct hourly effort on the project. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the current average rate of a personnel group with a similar job description. For faculty, if the effort occurs during the academic year and crosses departmental lines, the salary will be in addition to the normal base salary. University policy allows faculty who perform work in addition to their academic contract to receive no more than 20% over the base salary. Costs for general support services such as grants and contracts administration, accounting, personnel, and purchasing and receiving, as well as clerical support of these functions, are included in the EERC facilities and administrative cost rate.

Fringe benefits are estimated on the basis of historical data. The fringe benefits actually charged consist of two components. The first component covers average vacation, holiday, and sick leave (VSL) for the EERC. This component is approved by the UND cognizant audit agency and charged as a percentage of direct labor for permanent staff employees eligible for VSL benefits. The second component covers actual expenses for items such as health, life, and unemployment insurance; social security matching; worker's compensation; and UND retirement contributions.

Travel

Travel is estimated on the basis of UND travel policies which can be found at: http://www.und.edu/dept/accounts/employeetravel.html. Estimates include General Services Administration (GSA) daily meal rates. Travel includes scheduled meetings and conference participation as indicated in the scope of work.

Communications (phones and postage)

Monthly telephone services and fax telephone lines are generally included in the facilities and administrative cost. Direct project cost includes line charges at remote locations, long-distance telephone, including fax-related long-distance calls; postage for regular, air, and express mail; and other data or document transportation costs.

Office (project-specific supplies)

General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are provided through a central storeroom at no cost to individual projects. Budgeted project office supplies include items specifically related to the project; this includes duplicating and printing.

Data Processing

Data processing includes items such as site licenses and computer software.

Supplies

Supplies in this category include scientific supply items such as chemicals, gases, glassware, and/or other project items such as nuts, bolts, and piping necessary for pilot plant operations. Other items also included are supplies such as computer disks, computer paper, memory chips, toner cartridges, maps, and other organizational materials required to complete the project.

Instructional/Research

This category includes subscriptions, books, and reference materials necessary to the project.

Fees

Laboratory and analytical fees are established and approved at the beginning of each fiscal year, and charges are based on a per sample or hourly rate depending on the analytical services performed. Additionally, laboratory analyses may be performed outside the University when necessary.

Graphics services fees are based on an established per hour rate for overall graphics production such as report figures, posters for poster sessions, standard word or table slides, simple maps, schematic slides, desktop publishing, photographs, and printing or copying.

Shop and operation fees are for expenses directly associated with the operation of the pilot plant facility. These fees cover such items as training, safety (protective eye glasses, boots, gloves), and physicals for pilot plant and shop personnel.

General

Freight expenditures generally occur for outgoing items and field sample shipments.

Membership fees (if included) are for memberships in technical areas directly related to work on this project. Technical journals and newsletters received as a result of a membership are used throughout development and execution of the project as well as by the research team directly involved in project activity.

General expenditures for project meetings, workshops, and conferences where the primary purpose is dissemination of technical information may include costs of food (some of which may exceed the institutional limit), transportation, rental of facilities, and other items incidental to such meetings or conferences.

Facilities and Administrative Cost

The facilities and administrative rate (indirect cost rate) included in this proposal is the rate that became effective July 1, 2002. Facilities and administrative cost is calculated on modified total direct costs (MTDC). MTDC is defined as total direct costs less individual items of equipment in excess of $5000 and subcontracts/subgrants in excess of the first $25,000 for each award.