Big Sky Carbon Sequestration Partnership

Quarterly Report for period April 1, 2004 – June 30, 2004

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ABSTRACT

The Big Sky Carbon Sequestration Partnership, led by Montana State University, is comprised of research institutions, public entities and private sectors organizations, and the Confederated Salish and Kootenai Tribes and the Nez Perce Tribe. Efforts under this Partnership fall into four areas: evaluation of sources and carbon sequestration sinks; development of GIS-based reporting framework; designing an integrated suite of monitoring, measuring, and verification technologies; and initiating a comprehensive education and outreach program. At the first two Partnership meetings the groundwork was put in place to provide an assessment of capture and storage capabilities for CO_2 utilizing the resources found in the Partnership region (both geological and terrestrial sinks), that would complement the ongoing DOE research. During the third quarter, planning efforts are underway for the next Partnership meeting which will showcase the architecture of the GIS framework and initial results for sources and sinks, discuss the methods and analysis underway for assessing geological and terrestrial sequestration potentials. The meeting will conclude with an ASME workshop (see attached agenda).

The region has a diverse array of geological formations that could provide storage options for carbon in one or more of its three states. Likewise, initial estimates of terrestrial sinks indicate a vast potential for increasing and maintaining soil C on forested, agricultural, and reclaimed lands. Both options include the potential for offsetting economic benefits to industry and society. Steps have been taken to assure that the GIS-based framework is consistent among types of sinks within the Big Sky Partnership area and with the efforts of other western DOE partnerships. Efforts are also being made to find funding to include Wyoming in the coverage areas for both geological and terrestrial sinks and sources.

The Partnership recognizes the critical importance of measurement, monitoring, and verification technologies to support not only carbon trading but all policies and programs that DOE and other agencies may want to pursue in support of GHG mitigation. The efforts begun in developing and implementing MMV technologies for geological sequestration reflect this concern. Research is also underway to identify and validate best management practices for soil C in the Partnership region, and to design a risk/cost effectiveness framework to make comparative assessments of each viable sink, taking into account economic costs, offsetting benefits, scale of sequestration opportunities, spatial and time dimensions, environmental risks, and long-term viability. Scientifically sound information on MMV is critical for public acceptance of these technologies.

Two key deliverables were completed in the second quarter—a literature review/database to assess the soil carbon on rangelands, and the draft protocols, contracting options for soil carbon trading. The protocols developed for soil carbon trading are unique and provide a key component of the mechanisms that might be used to efficiently sequester GHG and reduce CO_2 concentrations. While no key deliverables were due during the third quarter, progress on other deliverables is noted in the PowerPoint presentations and in this report. A series of meetings held during the second and third quarters have laid the foundations for assessing the issues surrounding carbon sequestration in this region, the need for a holistic approach to meeting energy demands and economic development potential, and the implementation of government programs or a market-based setting for soil C credits. These meetings provide a connection to stakeholders in the region and a basis on which to draw for the DOE PEIS hearings. A third

Partnership meeting has been planned for August 04 in Idaho Falls; a preliminary agenda is attached.

The education and outreach efforts have resulted in a comprehensive plan which serves as a guide for implementing the outreach activities under Phase I. The public website is established (www.bigskyco2.org), along with a partnership logo. We have made presentations to stakeholders and policy makers including participation in the June PEIS meeting in Bozeman, connections to other federal and state agencies concerned with GHG emissions, climate change, and efficient and environmentally-friendly energy production. In addition, the Partnership has plans for integration of our outreach efforts with the students, especially at the tribal colleges and at the universities involved in our Partnership. This includes collaboration with the film and media arts departments at MSU and with the U.S.-Norway Summer School, extended outreach efforts at LANL and INEEL, and with the student section of the ASME. Finally, the Big Sky Partnership was involved in two key forums: the NETL Carbon Sequestration Conference (May 04) and a special session sponsored by the Western Governors' Association at the annual Western Governors' meeting on carbon sequestration. The session was chaired by Governor Rounds from South Dakota. Presentations are posted on our website. The Partnership was also involved in the planning and kickoff meeting for the U.S.-Norway bilaterals held in May in New Orleans in an effort to facilitate an exchange of research and students/faculty.

TABLE OF CONTENTS

INTRODUCTION

The Big Sky Regional Carbon Sequestration Partnership was initially called the Northern Rockies and Great Plains Regional Carbon Sequestration Partnership. The proposed name change was initiated in December 2003, and has received DOE/NETL approval. The Big Sky Partnership, led by Montana State University, Bozeman, MT, seeks to: identify and catalogue CO_2 sources and promising geologic and terrestrial storage sites, develop a risk assessment and decision support framework to optimize the areas' carbon-storage portfolio, enhance market-based carbon-storage methods, identify and measure advanced greenhouse gas-measurement technologies to improve verification, support voluntary trading and stimulate economic development, call upon community leaders to define carbon-sequestration strategies, and create forums that involve the public. Idaho, Montana and South Dakota are currently served by this Partnership that is comprised of 13 organizations and the Confederated Salish and Kootenai Tribes and the Nez Perce Tribe. Additional collaboration is being sought with neighboring states and Canada, and with other private and non-profit entities. To date, we are in the process of securing formal agreements with Puget Sound Energy and University of Wyoming/State of Wyoming. Montana Tech-Montana Bureau of Mines and Geology and the Idaho Carbon Sequestration Advisory Committee/Idaho Soil Conservation Commission are new members of the Partnership. Inland Northwest Research Alliance (INRA) and Western Governors' Association (WGA) are have provided support for our Partnership since the onset and are included as members of the partnership.

Original Partners include

Montana State University
Boise State University
South Dakota School of Mines and Technology
Texas A&M
University of Idaho
The Sampson Group
EnTech Strategies
Environmental Financial Products
Nez Perce Tribe
The Confederated Salish and Kootenai Tribes
Idaho National Engineering and Environmental Laboratory
Los Alamos National Laboratory
Montana Governor's Carbon Sequestration Working Group
National Carbon Offset Coalition

New Partners include

Idaho Carbon Sequestration Advisory Committee/Idaho Soil Conservation Commission
Inland Northwest Research Alliance
Montana Tech-Montana Bureau of Mines and Geology
Western Governors' Association

New Partners (in progress) include

Puget Sound Energy
University of Wyoming/State of Wyoming

EXECUTIVE SUMMARY

For reporting purposes, the activities and results for the Big Sky Partnership are organized into four somewhat overlapping components or efforts:

1. Evaluation of sources and potential for carbon sequestration sinks;
2. Development of GIS-based framework and the carbon cyberinfrastructure efforts;
3. Advanced concepts for monitoring, measuring, and verification, as well as for implementation, carbon trading, and evaluation; and
4. Education and outreach efforts.

The Partnership held their first meeting in Bozeman in October, 2003; the agenda included a discussion of the roles and contributions of each partner, the process of creating continuity among the geological and terrestrial efforts to provide a comprehensive assessment of capture and storage capabilities, and the unique contributions and research that our Partnership could provide to the DOE efforts. The subsequent efforts during the first three months of the grant focused on startup activities in each of the four areas. It was noted that the reporting in this first quarter was somewhat abbreviated due to the delayed funding for the two DOE labs, INEEL and LANL.

A second Partnership meeting was held on March 1-3, 2004 at Los Alamos National Lab. The agenda for the meeting included Partnership reports, evaluation of progress and assessment of coverage, Phase II strategic planning, LANL overview and collaborations, and seminar presentations. A copy of the agenda was included with the second quarter report.

The Big Sky Partnership has had Partnership recognition at two key meetings during the third quarter: the DOE/NETL Annual Carbon Sequestration conference in May, 2004, and the Western Governors' Annual Meeting in June 2004. Other presentations are listed with the materials for this third quarterly report.

Evaluation of sources and sinks. Activities during the third performance period were focused on the methodologies for characterizing the potential for geological and terrestrial sequestration sinks and identifying and cataloging industrial and agricultural GHG sources. In particular, the partnership has established a geological sink assessment approach and screening criteria, and nearing completion on compiling county-level data on tillage and land use for the terrestrial component. Both the geological and terrestrial component is resulting in data layers that will allow us to assess the suitability for carbon sequestration in the Big Sky Partnership region as well as the potential for locating future energy facilities in our region.

For geological sinks, the potential for subsurface formation of carbon dioxide sequestration focused on solubility and mineralization trapping, and examined the technical feasibility, the time frame until implementation, and offsetting economic benefits. For the terrestrial sinks, the methodologies have been focusing on both technical and economic feasibility. Increasing soil C levels are dependent upon both the technical capacity of the soils to sequester and utilize additional carbon, and the incentives provided for landowners to change land use management practices. Activities to identify sources and assessment of transportation infrastructure are

currently focused on identifying the state and federal databases and agencies, and addressing uncertainties inherent in matching/combining data sources.

GIS-based efforts. The GIS activities have involved LANL and INEEL as well as the research universities, and are focusing on building a database to meet the immediate modeling and Efforts focus on building a database to meet immediate Big Sky modeling and analysis needs, and on planning for multi-partnership, NATCARB, DOE, and national coordination, in the context of the emerging national cyberinfrastructure. We also have a major effort to examine the potential for using GIS-based systems in both research and outreach/education efforts of the Partnership, and the development of complimentary efforts with the West and Southwest partnerships.

Due to the resignation of Dr. Richard Aspinall (MSU) the overall coordination responsibilities for the GIS efforts and the development of our carbon atlas have been taken on by LANL, Dr. Paul Rich.

Advanced Concepts. The Partnership recognizes the critical importance of measurement, monitoring, and verification technologies to support not only carbon trading but all policies and programs that DOE and other agencies may want to pursue in support of GHG mitigation. For terrestrial sequestration, research is validating best management practices for soil C in the partnership region. A team of researchers from MSU have been working in the field to obtain field scale carbon estimates for ground truthing simulation models and identifying BMPs. Results from this research will also be used to validate the potential of soils to store carbon, and validate the Century Model predictions for soil C sequestration rates. Results will be presented at the August 04 Partnership meeting and at the INRA Symposium in September, 2004. A seminar was presented at the second annual Partnership meeting on the modeling framework for determining soil C supplies and the links to monitoring and measurement efforts.

Monitoring and Measurement Verification (MMV) activities this period, as they pertain to geological (and terrestrial) sinks, include some initial assessment of the state of the art for technologies that have a high likelihood of being mature enough to be applicable in Phase II small scale applications, and designing a risk/cost effectiveness framework to make comparative assessments of each viable sink, taking into account economic costs, offsetting benefits, scale of sequestration opportunities, spatial and time dimensions, environmental risks, and long-term viability. In conjunction with the GIS efforts and ongoing research at LANL, MSU, SDSMT, and INEEL, the Partnership is developing a well-integrated ensemble of diagnostics for MMV at each potential geological sequestration site, and a protocol for the terrestrial sequestration areas.

Regulatory and compliance research is being coordinated with the State agencies and with the IOGCC. We will be attending the IOGCC meeting in Chicago in late August, 2004.

With the arrival of funding during this quarter, LANL was able to begin work in the areas of geologic sequestration and advanced concepts such as mineralization. A write-up was prepared that performed an initial examination of various mineralization concepts. These included:

1) Industrial Mineralization
2) In Situ Mineralization

3) Brine Mineralization
4) Carbonate Dissolution
5) Trona Carbonation

All these concepts fall into the category of advanced concepts and all were found to require considerable further research and development work before they could be implemented on a practical scale and/or their long-term storage capabilities could be fully understood.

During the third reporting period the National Carbon Offset Coalition (NCOC) continued to expand the number and diversity of participants in its landowner/emitter advisory committee. Meetings were held with National Governors Association Greenhouse Gas Working Group, the Intertribal Environmental Council, and the U.S. Environmental Protection Agency. NCOC contractors attended and participated in a carbon sequestration conference sponsored by the state of Wyoming. NCOC contractors and a representative of the NCOC Board of Directors met with the Congressional delegation of the states of Montana and Idaho. NCOC contractors assisted in the development of an additional state of Montana grant designed to bring the Montana Bureau of Mines into the Partnership and expand the Partnership's geologic sequestration portion efforts. NCOC contractors worked with the Intertribal Environmental Council to develop a USDA proposal to create a 1605B Clearing House, conduct Greenhouse Gas workshops nationally with the tribes, and create a national Tribal Forestry Portfolio. Also during this reporting period NCOC began discussions with a national carbon trading group to begin marketing of NCOC carbon sequestration portfolios in DOE Phase II on the Chicago Climate Exchange (CCX) and other emerging markets. A meeting is planned next quarter to finalize contractual issues.

Draft planning forms, contracting options and a draft forestry portfolio were submitted to the Chicago Climate Exchange for review. After review by CCX and a follow-up conference call between CCX staff and NCOC contactors a second draft is now under development

The first meeting was held with a Montana based farmer/producer group to act as an advisory committee for the development of cropland/agricultural soils protocols planning standards and contracting options this reporting period. Work has begun on the Project Planning handbooks which will ultimately incorporate all deliverables.

Education and Outreach. The primary goal of the Education and Outreach efforts is to increase awareness, understanding, and public acceptance of carbon sequestration while building support for the efforts of the Partnership. The activities to date include the completion of a comprehensive Education and Outreach Plan (see Appendix), a Partnership listserv, the development of an internal website, development of handout materials for many of the conferences, planning and designing outreach and education materials in conjunction with the universities and other partners throughout the States, and the design and development of the public website and Partnership logo.

Other progress/efforts include: design and production of posters and fact sheets (see Appendix); meetings with environmental groups including the Greater Yellowstone Coalition; participation in monthly Outreach conference calls; participation in the Bozeman PEIS meetings and development of Partnership materials; and design of a student-oriented ASME workshop.

An advisory committee that includes representation from local constituencies is being formed, with the first meeting tentatively planned for Fall, 2004. Names have been submitted and selection process will be on the agenda at the Partnership meeting in August 2004.

EXPERIMENTAL SECTION

This section highlights the research that has been initiated that supports the objectives of the Partnership. During this performance period all Partners were able to contribute to the efforts and the combined progress is noted below.

Activities during the second and third performance periods continue with the development of the methodology for characterizing the potential of subsurface formation for carbon dioxide sequestration via solubility and mineralization trapping. As noted in the first quarterly report, the approach relies upon the use of bulk whole rock chemical analyses for formation geomedia. (See references from the first report.)

The Big Sky Partnership is securing public domain information about potential geologic carbon sequestration sites, and working with industry representatives. For regional sources, we have completed the compilation of state-level aggregate data regarding emissions from fossil fuel consumption, using EIA state data. Facility-level data for energy utilities and selected industries have been compiled for South Dakota, and this will serve as a template for the other states in our Partnership. Data on CH_4 from stationary and mobile combustion sources, oil and gas production, enteric fermentation and manure management, burning of agricultural wastes, and wastewater treatment, as well as data on N_2O emissions from similar sources have been compiled for South Dakota. This information will be incorporated into the GIS database for the Big Sky Partnership.

During the third performance period the overall approach to conduct assessments of geologic carbon sequestration potential was further refined. We are using a two-phased approach for the assessment of regional geologic carbon dioxide sinks. The first phase is the identification of geologic 'plays'[1] that are screened against carbon dioxide injectability and capacity criteria. The screening eliminates plays that do meet minimum criteria. The remaining plays will be subjected to a detailed analysis to evaluate (using numerical hydrogeochemical modeling) their carbon dioxide trapping potential. In addition, an economic and regulatory feasibility analysis will be conducted. The results of the screening and analysis will be incorporated into a GIS database.

Also under the geological sequestration component of the partnership work, we are reviewing geophysical methods for monitoring the pre-injection and injection (i.e., production) phases of subsurface carbon sequestration in deep reservoirs. We are reviewing methods that are applicable for (a) single-well testing as would occur with a pilot project of small scale and could

[1] The fundamental geologic unit used in the 1995 National Oil and Gas Assessment was the 'play', which is defined as a set of known or postulated oil and or gas accumulations sharing similar geologic, geographic, and temporal properties, such as source rock, migration pathways, timing, trapping mechanism, and hydrocarbon type.

occur in a larger production-scale project; (b) cross-hole testing including tomographic and time-lapse tomographic methods; and (c) passive and active surface seismic monitoring or testing that can track the presence and movement of supercritical carbon dioxide. We plan to make a presentation on these findings at the Partnership meeting in Idaho Falls in August.

We are also continuing to review published information on basins in the Big Sky Carbon Sequestration Partnership region. As a first step in evaluation for a familiar basin, we have reviewed published information on the western Snake River Plain as a potential geologic province for carbon sequestration and we have determined that the patchy nature of both the fluvio-lacustrine environments and the potential cap rocks on them in the basin make this province quite risky for large-scale, deep-reservoir, geologic carbon sequestration.

A meeting with researchers at Los Alamos National Laboratory (LANL) was held to discuss the availability of empirically-based reaction kinetics for carbon dioxide facilitated weathering of geologic material. This meeting resulted in an a collaborative effort to advance the state of understanding regarding carbon dioxide enhanced weathering of geologic material in potential sequestration sites. The research group at Los Alamos has developed an experimental technique through which reaction kinetics can be derived for carbon dioxide facilitated weathering of geologic materials. The application of this data to field scale sequestration modeling effort currently in progress by the Big Sky Partnership could prove invaluable to a Phase II to field deployment.

In addition, an economic and regulatory feasibility analysis is being conducted to determine sites that are suitable both geologically and economically. The results of the screening and analysis will be incorporated into a GIS database.

As stated in the last quarterly report, efforts have been continued to identify sources and databases containing pertinent information for the characterization of each of the plays and information relative to the screening criteria. There are two primary databases containing much of the information needed for Wyoming and Montana, 1) The Wyoming Oil and Gas Conservation Commission web site and 2) Montana Board of Oil and Gas Conservation web site. Screening criteria parameters expected to be collected from these agencies include depth, pressure, temperature, fluid properties, unit thickness, salinity, pH, porosity, permeability, and gas content. Efforts have begun in extracting this information and organizing it into a GIS database that will show the spatial distribution of these characteristics. Other research activities are being conducted to gather the rock type and whole rock chemistry relative to each of the geologic formations within each of the plays.

A second area of work has been to evaluate and verify the soil C potentials with the estimates forthcoming from the Century simulation model. During the second performance period, the results of the terrestrial sinks assessment for South Dakota has been completed using the SSURGO soil texture grids and is being summarized; the evaluation of soil C potential on croplands in Montana is currently underway (see related material below). During the third performance period we have completed the SSURGO soil texture grids for Montana and Idaho; the CLIMATE data compilation is in progress.

For forested lands, the USFS data on forest carbon stocks by state, by major species is available and ready to be incorporated into the GIS database. We have been compiling NLDC time series data to determine forest area change, for use in assessing forest sink potential.

We are integrating soil and climate databases with our econometric simulation models to estimate soil carbon trajectories at the MLRA level in Montana, and to test the impact of alternative management scenarios and carbon policy scenarios on the cost of sequestering soil C and on the size of the terrestrial sinks. During the second performance period we have developed a yield based framework for using US Ag census data to predict land use changes, soil carbon changes under alternative price and climate change scenarios. The third performance period focuses on modifying and validating these empirical results. Results were presented at the May DOE carbon sequestration meeting and will be presented at the INRA workshop in September 2004.

For rangeland sequestration, work is in progress on undertaking a literature review on rangeland options and how rangeland management practices relate to changes in levels of soil C. Rangelands comprise a sizeable portion of the land resources in our partnership region and are of critical importance to our neighboring states. Preliminary estimates suggest that rangelands can store up to an additional 0.3 mg C/ha/yr and restores grasslands storing nearly twice that amount. Possible options that have been identified for rangeland carbon storage to date include juniper invasion control, mesquite invasion, and cheatgrass control. These options along with baseline estimates of soil C levels at the MLRA level are being compiled by Texas A&M colleagues for inclusion with the GIS terrestrial sink inventory.

In order to estimate areas of potential carbon sequestration or loss, data for use in a GIS is being acquired. This data includes 1990's Landsat TM data (30 m resolution) that identifies 21 classes of land cover types. For rangelands, land cover types designated as shrublands, grassland/ herbaceous, and pasture/hay are being considered. These classes will be intersected with MLRAs to define acres within each MLRA and linked with other datasets such as STATSGO soil and MODIS net primary productivity.

Field-scale studies were established at six farm fields in the Golden Triangle in north central Montana, and researchers have been working on a weekly basis with producers in the study sites with field management and soil carbon sampling. The purpose of these studies is to determine the effect of cropping intensity (annual vs. alternate year) and tillage (conventional vs. no-till) on soil C levels across different soil types and terrains.

Efforts have focused on carbon measurements using the following experimental plan: At each farm, a field of 32 ha was divided into four strips (8 ha) representing the following cropping/tillage systems: traditional summer-fallow – wheat; no till chemical fallow – wheat; conventional tillage pea-wheat; and no till pea-wheat. Within each strip four sites were identified for sampling/monitoring of soil carbon changes over time. The sites (total of 16 per farm) were georeferenced via GPS. Soil samples are collected on a two-year time interval beginning with the initial background sampling in the Fall of 2002. A more detailed description of the experimental plan was included in the second quarterly report.

Efforts are proceeding with the compilation of information relevant to point and terrestrial area sources of GHGs in MT and integration into a GIS framework as appropriate. INEEL/UI/BSU are coordinating efforts to collect spatially-referenced data for geological formations. The Partnership is assembling soil, climate, crop and land use databases and integrating these data with the C-Lock system developed by SDSMT and with economic data on land use practices and the economic frameworks developed at MSU for quantifying soil carbon sequestration potential. Furthermore, these efforts are being coordinated with the other Western partnerships.

GIS data compilation for Big Sky is being driven primarily by needs for analysis and modeling. LANL GIS Lab team leader Paul Rich assumed the role of coordination of GIS efforts for the Big Sky Region, after Richard Aspinall departed from MSU. Randy Lee continues as the GIS lead for geologic data and Maribeth Price (SDSMT) continues as the GIS lead for terrestrial data. Based on additional planning, the LANL Big Sky GIS effort will focus primarily on planning and coordination, in particular 1) facilitation of GIS database implementation, 2) facilitation of multi-partner cyberinfrastructure development including links to NATCARB, 3) assistance with demonstration analyses and visualization using the database, and 4) assistance with multi-partner outreach efforts. Specific LANL GIS planning activities to date include 1) discussions/meeting with NATCARB lead Tim Carr, 2) planning sessions via teleconference involving Big Sky GIS personnel, 3) coordination with SW partnership and WGA via discussions with Dennis Goreham; 4) participation in multi-partnership GIS working group teleconferences; 5) meeting with Michael Goodchild (UCSB) to discuss relations with national cyberinfrastructure efforts and enterprise GIS design (Keating et al. 2003, Witkowski et al. 2004); and 6) a presentation concerning cross-complex DOE GIS coordination at the Annual Information Management Conference, Columbus, OH, June 9, 2004 (Bollinger et al. 2004).

Advanced concept activities this period include designing integrated measurement, monitoring, and verification for geological and terrestrial sinks, regulatory protocols, and risk assessment/tradeoff frameworks. Measurement, monitoring, and verification activities, and capture technologies, are complementing ongoing research at the labs and research institutions; to date we have assessed the focus and extent of these research efforts. The direction of the MMV research was discussed in detail the first quarterly report.

Some of the ongoing efforts at LANL on Advanced concepts include an initial examination of various mineralization concepts. These included:

1) Industrial Mineralization
2) In Situ Mineralization
3) Brine Mineralization
4) Carbonate Dissolution
5) Trona Carbonation

All these concepts fall into the category of advanced concepts and all were found to require considerable further research and development work before they could be implemented on a practical scale and/or their long-term storage capabilities could be fully understood.

The reaction rates for industrial mineralization of CO_2 are still too slow to prove to be an effective option. Although rates that can be obtained today are at the margins of becoming acceptable, achieving these rates involves still requires large (and costly) energy inputs that would prove uneconomical. New ideas and approaches are still being developed and pursued. It is believed that with further R&D, a viable approach can be found.

The reaction rates for in-situ mineralization tend to be even lower than in the industrial mineralization case as one has very limited or no ability to achieve the most favorable operating conditions. Nonetheless, given the virtually limitless source of resources available in the region, further examination of this approach is still warranted.

Brine mineralization is appealing from a conceptual point of view especially since huge quantities of brine are available deep underground. However, the brines tend to be dominated by non reactive salts and only a very small fraction of the dissolved minerals are likely to be able to be transformed into stable carbonates without the addition of other costly chemicals. The use of any reactive chemicals other than catalysts are likely to ruled out when one considers the amount of CO_2 that must be disposed of. Isolated pockets of more favorable brines could nonetheless be found.

The dissolution of calcium carbonate (limestone) in carbonic acid to form a dissolved calcium bicarbonate solution that holds down additional CO_2 has been discussed in the literature. This is a process involved in the formation of limestone caves. However, the long-term fate of the temporarily dissolved CO_2 is still uncertain and vast amounts of water would be required unless one were able to maintain high CO_2 pressure throughout the duration of the sequestration period.

Trona carbonation is a sodium-based version of the above process and would allow one to store the CO_2 in the mineral form of solid sodium bicarbonate. It has the advantage of requiring far lower CO_2 pressures if the system were damp and concentrated, and no CO_2 pressure if kept dry. Extensive deposits of trona exist in Wyoming, which would allow extensive storage for the region. At the same time, the deposits are too small to provide a long-term national solution.

In addition to this work, Travis L. McLing from Idaho National Engineering and Environmental Laboratory visited LANL. He met with Don Dreesen to discuss advanced drilling and monitoring capabilities that might be employed in the geological sequestration area. He also met with Hans Ziock to discuss various advanced concepts, issues associated with coal bed methane, and requirements needed to deal with the scale of the storage requirement and the issues associated with the long term storage requirements.

Finally, discussions and interactions were held with the internally sponsored LANL team working on geological sequestration which is studying issues of porous flow, interactions between the host and capping rocks, and the water-CO_2 system that would result from geological sequestration.

During the reporting period the National Carbon Offset Coalition (NCOC) continued to expand the number and diversity of participants in its landowner/emitter advisory committee. Meetings were held with National Governors Association Greenhouse Gas working Group, the Intertribal

Environmental Council, and the U.S, Environmental Protection Agency. NCOC contractors attended and participated in a carbon sequestration conference sponsored by the state of Wyoming. NCOC contractors and a representative of the NCOC Board of Directors met with the Congressional delegation of the states of Montana, and Idaho. NCOC contractors assisted in the development of an additional state of Montana grant designed to bring the Montana Bureau of Mines into the Partnership and expand the partnerships geologic sequestration portion efforts. NCOC contractors worked with the Intertribal Environmental Council to develop a USDA proposal to create a 1605B Clearing House, conduct Greenhouse Gas workshops nationally with the tribes, and create a national Tribal Forestry Portfolio. This reporting period NCOC also began discussions with a national carbon trading group to begin marketing of NCOC carbon sequestration portfolios in DOE Phase II on the CCX and other emerging markets. A meeting is planned next quarter to finalize contractual issues

During this reporting period draft planning forms, contracting options and a draft forestry portfolio were submitted to the Chicago Climate. Exchange for review. After review by CCX and a follow-up conference call between CCX staff and NCOC contactors a second draft is now under development.

Work has begun on the Project Planning handbooks which will ultimately incorporate all deliverables. The work being conducted for overall objective is design of proposed protocols planning standards, and contracting options based on input from specialists in the area greenhouse gas emission reduction policy, science and the carbon market. Dr. Brandle's work on overall objective 2, the development of volume tables relies on collection of field data from previously selected sites across Montana. Field data collection is accomplished through selecting representative samples for an identified number of key species. The filed work involves actual cutting down measuring and weighing selected key species at each site. Field data is then complied into volume tables for the selected species by using existing volume tables in the region.

The education and outreach activities during this performance period for this component include the completion of the Education and Outreach Plan, which was revised in response to DOE and other outside review, a Partnership listserv, and the development of an internal and external website. A public website for the Big Sky Partnership was launched in the third quarter. The web site address is www.bigskyco2.org. In addition, enhanced collaboration with the University community through visiting appointments, seminar series, and co-sponsored activities at professional meetings is underway.

We have met with the MSU film and media arts department to commission a film on carbon sequestration alternatives. This film is tentatively scheduled for production during the 2004-05 academic school year.

RESULTS AND DISCUSSION

GIS data compilation for Big Sky is being driven primarily by needs for analysis and modeling. Based on additional planning, the Big Sky GIS effort will focus primarily on planning and coordination, in particular 1) facilitation of GIS database implementation, 2) facilitation of multi-

partner cyberinfrastructure development including links to NATCARB, 3) assistance with demonstration analyses and visualization using the database, and 4) assistance with multi-partner outreach efforts. Specific GIS planning activities to date include discussions/meeting with NATCARB lead Tim Carr, planning sessions via teleconference involving Big Sky GIS personnel, and coordination with SW partnership and WGA;

Geographic Information System (GIS) data have been acquired for possible geological sink areas in the Big Sky Partnership geographic area. These data were defined during the 1995 National Assessment of United States Oil and Gas Resources conducted by the U.S. Geological Survey. The National Assessment identified oil and gas producing areas at a Province or Basin scale. In the Big Sky Carbon Sequestration Partnership ten Provinces were identified.

GIS layers at the next level of resolution, 'play', were also downloaded from the USGS National Oil and Gas Assessment website. Fully compliant Federal Geographic Data Committee (FGDC) Metadata for the two sets of GIS data layers were also downloaded. These GIS data layers will be used to perform an initial assessment to determine suitability for carbon sequestration.

Preliminary results for terrestrial sequestration sinks indicate that the soils in our Partnership region have the capacity to store and productively utilize more soil C. However, the potential "size" of these sinks depends upon many biophysical and economic factors and the design of the policies and programs that are in place to sequester carbon. Our research is making inroads to better understanding the incentives that producers and land-use managers face in our Partnership region. Preliminary results have been reported at many workshops. These are noted under presentations.

As noted in the first quarterly report, an initial vision statement for the GIS efforts and a GIS Road Map was completed and was being reviewed by the Partnership. This has been adopted by the Partnership. The BSP-CC group, which was formed in response to the needs of the Big Sky Partnership, is unique in its integrated focus on providing core data for constructing map-based data layers for identifying source and sinks, as well as a framework for modeling results that are more transparent to policy makers, and for outreach and education purposes that reach all segments of society. GIS will be used to synthesize all aspects of carbon science and decision support for improved policy analysis and outreach. The BSP-CC group will serve as a liaison with other GIS efforts among the DOE western Partnerships and within the DOE carbon sequestration program.

CONCLUSIONS

During the first six months, the Big Sky Partnership initiated activities in four areas: evaluation of sources and carbon sequestration sinks; development of GIS-based reporting framework; designing an integrated suite of monitoring, measuring, and verification technologies; and initiating a comprehensive education and outreach program. The groundwork was put in place to provide a comprehensive assessment of capture and storage capabilities for CO_2 utilizing the resources found in the Partnership region (both geological and terrestrial sinks). Steps have been taken to assure that the GIS-based framework is consistent among types of sinks within the Big Sky Partnership area and with the efforts of other western DOE partnerships. Efforts are

also being made to find funding to include Wyoming in the coverage areas for both geological and terrestrial sinks and sources.

These activities are putting in place a map-based integrated information management system for our Partnership, with transferability to the national carbon sequestration efforts. This framework will also be critically important to the evaluation of future sequestration technologies, which by necessity must utilize simulation modeling and other related techniques for assessing environmental impacts and cost effectiveness.

The Partnership recognizes the critical importance of measurement, monitoring, and verification technologies to support not only carbon trading but all policies and programs that DOE and other agencies may want to pursue in support of GHG mitigation. The efforts begun in developing and implementing MMV technologies for geological sequestration reflect this concern. Research is also underway to identify and validate best management practices for soil C in the partnership region, and to design a risk/cost effectiveness framework to make comparative assessments of each viable sink, taking into account economic costs, offsetting benefits, scale of sequestration opportunities, spatial and time dimensions, environmental risks, and long term viability. Scientifically sound information on MMV is critical for public acceptance of these technologies.

A series of meetings held since the Partnership's inception have laid the foundations for assessing the issues surrounding the implementation of a market-based setting for soil C credits. These include the impact of existing local, state, and federal permitting issues for terrestrial based carbon sequestration projects, consistency of final protocols and planning standards with national requirements, and alignments of carbon sequestration projects with existing federal and state cost-share programs. These meetings provide a connection to stakeholders in the region.

Finally, the education and outreach efforts have resulted in a comprehensive plan which serves as a guide for implementing the outreach activities under Phase I. The primary goal of this plan is to increase awareness, understanding, and public acceptance of sequestration efforts and to build support for a constituent-based network which includes the initial Big Sky Partnership and other local and regional businesses and entities. Presentations about the Partnership have been made at the Western Governors' Annual meeting (June 04), the Western Energy Summit (April 04), the NETL/DOE carbon sequestration meeting (May 04) and in meetings with industry representatives. Fact sheets and posters were developed for these presentations (see Appendix). PowerPoint presentations are posted on our website (www.bigskyco2.org).

The public website makes available many of the presentations to stakeholders and policy makers, provides a connection to other federal and state agencies concerned with GHG emissions, climate change, and efficient and environmentally-friendly energy production. In addition, we have laid plans for integration of our outreach efforts with the students through the ASME workshop, the film and media arts departments at MSU, and with outreach efforts at LANL. Finally, both Pam Tomski, outreach coordinator, and Susan Capalbo, PI for the Big Sky Partnership are involved in U.S.-Norway bilaterals in an effort to provide for an exchange of research and students/faculty. In related efforts, Pam Tomski is heading up the plans for the first U.S./Norway Summer School to be held August 2004.

REFERENCES

Bollinger, J., S. Hargrove, P.M. Rich, L. Brady-Sabeff, D. Collette, A. Guber, M. Klein, J. Kuiper, J. Lee, R. Lee, K. Mickus, D. Morehouse, K. Moore, A. Ramsdell, S. Rush, J. Stewart, H. Walker, R. Wells. 2004. The DOE GIS Core Team. Annual Information Management Conference, Columbus, OH, June 9, 2004.

Keating, G.N., P.M. Rich, and M.S. Witkowski. 2003. Challenges for enterprise GIS. URISA 15:23-36.

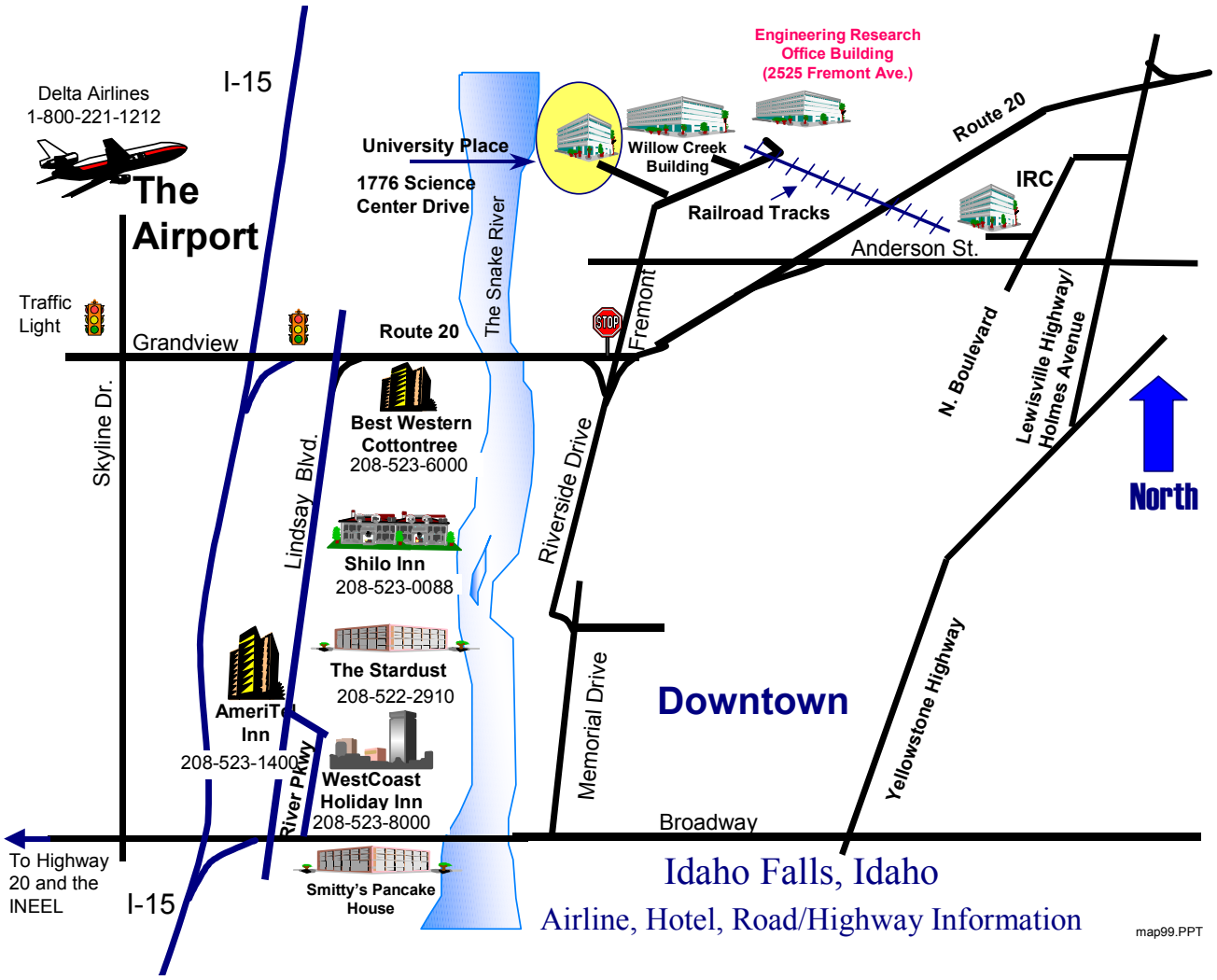
APPENDICES

The next Big Sky Partnership meeting will be held August 24-26, 2004 in Idaho Falls. We will meet in the Riverside room (TAB 350) at the Center for Higher Education (CHE), where Bob Smith (208-282-7954) is located. There is a SUB in an adjacent building where drinks, snacks, etc. are available. There is no need for badges, but the participants will need parking passes (INEEL will take care of this).

Working lunches will provide some flexibility in the presentation times.

Big Sky Carbon Sequestration Regional Partnership Agenda TAB 350 Conference Room at the Center for Higher Education		
Day 1 – Monday, August 23 (Travel Day)		
Day 2 –Tuesday, August 24		
Time	**Topic**	**Presenters**
7:45 – 8:00 AM	Coffee Reception	
8:00 – 8:30 AM	Welcome and INEEL R&D Overview	Paul Kearns, INEEL VP and Deputy Lab Director
8:30 – 9:30 AM	NETL Program Office	John Litynski, DOE-HQ
9:30 – 10:00 AM	Review Agenda/Meeting goals	Susan Capalbo, Partnership PI
10:00 AM – 12:00	Progress Report (Geologic)	INEEL, U of I, BSU, LANL
12:00 – 1:00 PM	Working Lunch	
1:00 – 2:30 PM	Progress Reports (GIS)	INEEL, SDSMT, LANL
2:30 – 3:30 PM	Progress Reports (MMV, Adv. Technologies)	LANL
3:30 – 5:30 PM	INEEL IRC Lab tour/Geocentrifuge	INEEL/U of I
6:00 – 8:00 PM	Dinner	Jakers Restaurant (Lindsay Ave)
Day 3 –Wednesday, August 25		
Time	**Topic**	**Presenters**
8:00 – 8:45 AM	Progress Reports (Carbon trading)	Ted Dodge, NCOC
8:45 – 9:30 AM	Progress Reports (Public Outreach)	Pam Tomski, EnTech Strategies
9:30 – 11:00 AM	Progress Reports (Terrestrial)	MSU, SDSMT, Texas A&M
11:00 – 12:00	Progress Reports (Regulatory Compliance)	MSU, LANL
12:00 – 1:00 PM	Working Lunch	
1:00 – 2:00 PM	Phase I Action Item review	all
2:00 – 3:00 PM	Fossil Energy at INEEL (H2, CO2, etc.)	Bruce Reynolds, INEEL FE Dept.
3:00 – 5:30 PM	SSI Presentations	INEEL/U of I
6:00 – 8:00 PM	Dinner	Sandpiper Restaurant (Lindsay)
Day 3 –Thursday, August 26		
Time	**Topic**	**Presenters**
8:00 – 9:30 AM	Discussions with Phase 2 participants	Wyoming, Idaho, others
10:00 AM – 12:00	Phase II Planning	All Phase II participants
12:00 – 1:00 PM	Working Lunch	
1:00 – 5:00 PM	ASME Carbon Sequestration Symposium held at the University Place Auditorium	Invited speakers, hosted by ASME (Separate agenda)

Additional details:
1. Local Idaho Falls map with CHE and building location, airport, and hotel locations in area.


Delta Airlines
1-800-221-1212
I-15
The Airport
Traffic Light
Grandview
Skyline Dr.
Route 20
University Place
1776 Science Center Drive
The Snake River
Engineering Research Office Building (2525 Fremont Ave.)
Willow Creek Building
Railroad Tracks
Route 20
IRC
Anderson St.
Fremont
STOP
N. Boulevard
Lewisville Highway/ Holmes Avenue
North
Best Western Cottontree
208-523-6000
Lindsay Blvd.
Riverside Drive
Shilo Inn
208-523-0088
The Stardust
208-522-2910
AmeriTel Inn
208-523-1400
River Pkwy
WestCoast Holiday Inn
208-523-8000
Memorial Drive
Downtown
Yellowstone Highway
Broadway
Smitty's Pancake House
To Highway 20 and the INEEL
I-15
Idaho Falls, Idaho
Airline, Hotel, Road/Highway Information
map99.PPT

ASME Carbon Sequestration Symposium

August 26, 2004 at University Place Auditorium

ASME Moderators: Karen Moore and David Shropshire

(1:00 - 3:00 PM)

Invited Carbon Sequestration Speakers
(15 min./person presentation + 5 min. for questions)

Anhar Karimjee, EPA's Carbon Sequestration effort
John Litynski (DOE), Carbon Sequestration Program
Susan Capalbo (MSU), Big Sky Partnership
Perry Miller (MSU), Terrestrial Sequestration
Robert Smith (U of I), Geologic Sequestration
Pamela Tomski (EnTech Strategies), Carbon Capture

(3:00 – 3:15 PM – Short Break)

(3:15 - 5:00 PM)

Panel Discussion for Big Sky Region
(10 min. presentation + question period)

David Ferguson, Idaho Carbon Sequestration Advisory Committee
George Vance, Wyoming Governors Committee on Carbon Sequestration
Mark Lindberg, Montana Governor's Office
Pat Zimmerman, South Dakota School of Mines & Technology
Ted Dodge, Indian Nation perspectives on carbon sequestration

Big Sky
CARBON SEQUESTRATION PARTNERSHIP

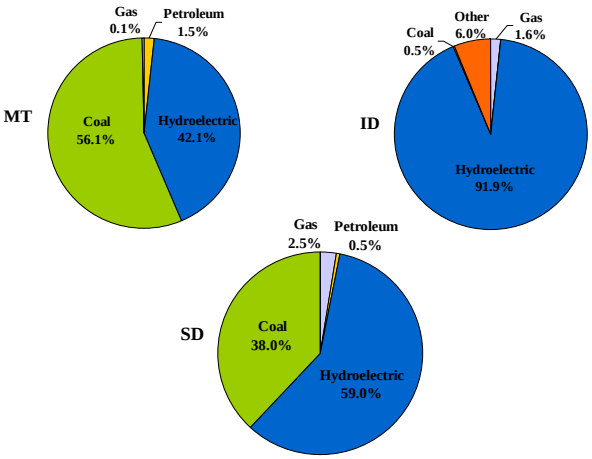
A new energy future for Montana, Idaho, South Dakota and the nation.

Led by Montana State University, the **Big Sky Partnership** is one of the U.S. Department of Energy's seven regional partnerships. To date, the Partnership includes Montana, Idaho and South Dakota, as well as contiguous parts of neighboring states and Canada.The Partnership is developing a framework to reduce carbon dioxide emissions that contribute to climate change and is working with stakeholders to create the vision for a new, sustainable energy future that cleanly meets the region's energy needs. Because energy is not an optional commodity, carbon sequestration will play an important role.

What is CO_2 Sequestration?

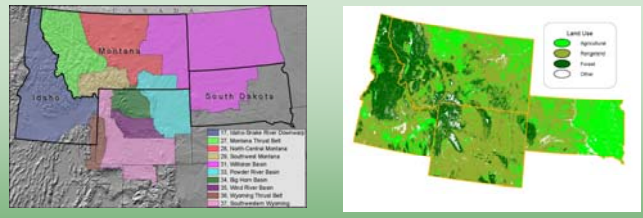
Carbon dioxide, CO_2, is a major by-product of energy use. Abundant coal and hydropower offer Montana, Idaho and South Dakota some of the lowest cost electricity in the nation. However, burning fossil fuels for transportation, electricity generation and manufacturing emits greenhouse gases (GHG) that may impact regional and global climate. "Carbon sequestration" is a family of methods for capturing and permanently isolating gases that otherwise could contribute to global climate change. Affordable and environmentally safe sequestration approaches could offer a way to stabilize atmospheric levels of carbon dioxide.

Electricity Generation & GHG Emissions in the Big Sky Region



Two Approaches To Carbon Sequestration

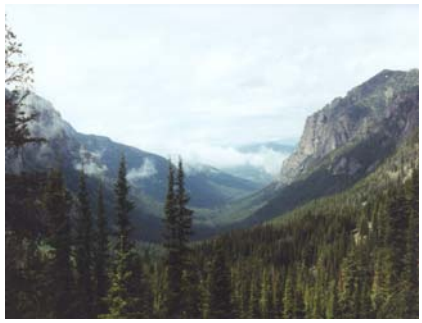
The **Big Sky Partnership** is researching two major types of carbon sequestration projects: **geologic** and **terrestrial**.



Geologic and **Terrestrial** Carbon Sequestration Potential in the Big Sky Region

Geologic sequestration involves storing carbon dioxide in geologic formations including oil and gas reservoirs, deep saline reservoirs and coal seams. These are structures that have stored crude oil, natural gas, brine and CO_2 for over millions of years. Many power plants and other large emitters of CO_2 are located near geologic formations that are amenable to CO_2 storage. In many cases the injection of CO_2 into a geologic formation can enhance the recovery of hydrocarbons, providing value-added by-products that can offset the cost of CO_2 capture and sequestration.

Terrestrial sequestration relies on management practices of agricultural lands, rangelands, forests and wetlands to remove CO_2 from the atmosphere via photosynthesis and at the same time reduce CO_2 emissions. No-till or reduced till methods, increased crop rotation intensity, the use of higher residue crops, cover crops or conservation measures are all means of increasing carbon storage in agricultural soils. Terrestrial sequestration reduces emissions while improving land and water quality, thus making soils healthier, more productive and less susceptible to large-scale CO_2 release. Enhancing the natural processes that remove CO_2 from the atmosphere is thought to be one of the most cost-effective means of reducing atmospheric levels of CO_2.



Regional Sequestration Opportunities

The objectives of the **Big Sky Partnership** fall into four areas:

- Evaluation of sources and carbon sequestration sinks with the goal of identifying viable projects;
- Development of GIS-based reporting framework;
- Designing an integrated suite of measuring, monitoring and verification technologies;
- Initiating a comprehensive education and outreach program aimed at connecting with communities and organizations within the region

The region has a diverse array of geologic formations that could provide storage options for carbon in one or more of its three states. Likewise, initial estimates of terrestrial sinks indicate a vast potential for increasing and maintaining soil C on forested, agricultural and reclaimed lands. Both options include the potential for offsetting economic benefits to industry and society.

Complementary to the efforts on evaluation of sources and sinks is the development of the **Big Sky Partnership** Carbon Cyberinfrastructure (BSP - CC) and a GIS Road Map for the Partnership. These efforts are putting in place a map-based integrated information management system or carbon atlas for our Partnership with transferability to the national carbon sequestration effort.

Measurement and Verification

The **Big Sky Partnership** recognizes the critical importance of measurement, monitoring and verification technologies to support not only carbon trading, but other policies and programs the DOE and other agencies may want to pursue in support of GHG mitigation. The efforts begun in developing and implementing MMV (measurement, monitoring and verification) technologies for geologic sequestration reflect this concern. Research is also underway to identify and validate best management practices for soil C in the Big Sky region, and to design a risk/cost effectiveness framework to make comparative assessments of each viable sink, taking into account economic costs, offsetting benefits, scale of sequestration opportunities, spatial and temporal dimensions, environmental risks and long term viability.

For More Information

Please visit our website: **www.bigskyco2.org** or contact:

Susan Capalbo, Director and PI of Big Sky Partnership, 207 Montana Hall, MSU, Bozeman, MT 59717-2460, 406-994-5619, scapalbo@montana.edu

Pamela Tomski, Big Sky Outreach Director, EnTech Strategies, LLC, 1862 Mintwood Place, NW #101, Washington, DC, 20009, 202-822-6120 ex. 11, ptomski@entech-strategies.com

Marketing Carbon Credits

The **Big Sky Partnership** is assessing the issues surrounding the implementation of a market-based setting for soil C credits. These include the impact of existing local, state and federal permitting issues for terrestrial-based carbon sequestration projects, consistency of final protocols and planning standards with national requirements, and alignments of carbon sequestration projects with existing federal and state cost-share programs.

Connecting with the Communities and Industry

The education and outreach efforts have resulted in a comprehensive plan whose primary goal is to increase awareness, understanding, and public acceptance of sequestration efforts and build support for a constituent-based network, which includes the initial **Big Sky Partnership** and other local and regional businesses and entities.

The Big Sky Partnership Team

- **Montana State University**
- **Boise State University**
- **EnTech Strategies, LLC**
- **National Carbon Offset Coalition**
- **South Dakota School of Mines & Technology**
- **Texas A & M University**
- **University of Idaho**
- **Idaho National Engineering and Environmental Laboratory (INEEL)**
- **Los Alamos National Laboratory (LANL)**
- **Inland Northwest Research Alliance (INRA)**
- **U.S. Department of Energy**
- **Montana Governor's Carbon Sequestration Working Group**
- **The Confederated Salish and Kootenai Tribes**
- **Nez Perce Tribe**
- **The Sampson Group**
- **Environmental Financial Products, LLC**
- **Idaho Carbon Sequestration Advisory Committee (ICSAC) / Idaho Soil Conservation Committee**
- **Montana Bureau of Mines and Geology**

Big Sky Regional Carbon Sequestration Partnership website – www.bigskyco2.org

Big Sky CARBON SEQUESTRATION PARTNERSHIP

Public Meeting

Programmatic Environmental Impact Statement: Carbon Sequestration

WHO: U.S. Department of Energy, (DOE) Office of Fossil Fuel

WHAT: A scoping meeting will give interested parties the opportunity to raise issues to be addressed in a Programmatic Environmental Impact Statement (EIS) on the DOE Carbon Sequestration Program, which is under development. The EIS will cover three areas:

1. The current state of greenhouse gases and their sources,
2. Potential problems resulting from greenhouse gas emissions, and
3. The role of DOE's Carbon Sequestration Program in addressing the problems of both a national and global scale.

The programmatic EIS will evaluate the potential environmental impacts of implementing the DOE Carbon Sequestration Program compared with other reasonable alternatives.

WHEN: Tuesday, June 8, 2004
5:00–7:00 p.m.
Informal, informational open house

7:00 p.m.
Public scoping meeting, with presentations by DOE representatives followed by opportunities for public comment

WHERE: Bozeman High School
205 North 11th Avenue
Bozeman, MT

HOW: Anyone is welcome to attend either portion of the meeting with or without advance notification. Attendees are not obligated to register or offer comments for the public record.

Individuals who would like to speak during the public scoping part of the meeting should register, either at the meeting or in advance by leaving a message on DOE's toll-free number of the carbon sequestration environmental impact statement: (877) 367-1521.

Public speakers will be called in the order they registered, and will be asked to limit their remarks to five minutes. Following completion of comments by registered speakers, the meeting will be open for additional comments, after which speakers who require more than five minutes will be invited to complete their statements.

DETAILS: For more information, please visit the following web sites:
www.fossil.energy.gov/programs/sequestration
www.netl.gov/coalpower/sequestration/index.html

(more)

Big Sky CARBON SEQUESTRATION PARTNERSHIP

Questions & Answers

Carbon Sequestration & the Program Environmental Impact Statement (EIS)

What is Carbon Sequestration?

Carbon sequestration involves capturing and permanently storing carbon dioxide (CO_2) gases that could otherwise contribute to global climate change. Affordable and environmentally safe approaches could offer a way to stabilize atmospheric levels of CO_2 without requiring potentially costly changes to the United States energy infrastructure.

What is DOE Doing to Develop Carbon Sequestration Technology?

DOE's Carbon Sequestration Program includes several efforts:

- ***The Carbon Sequestration Leadership Forum***, an international ministerial-level panel that meets regularly to discuss the growing body of scientific research and emerging technologies and to plan joint projects for carbon sequestration.
- ***Regional Partnerships Program***, a nationwide network of federal, state and private sector partnerships to determine the most suitable technologies, regulations and infrastructure for future carbon capture, storage and sequestration in different areas of the country.
- ***FutureGen***, a full-scale demonstration project that will capture and store CO_2, making it the world's first coal-fueled prototype power plant to incorporate carbon sequestration technologies.
- ***Carbon Sequestration Core R&D Program***, a portfolio of technologies that will capture and permanently store greenhouse gases.

How is Montana Involved?

Montana State University is leading the DOE Big Sky Carbon Sequestration Partnership, one of DOE's seven regional partnerships. The partnership is comprised of 14 public and private organizations including two Indian tribes. Funded with a $1.6-million DOE grant matched by $400,000 of state and regional dollars, the Partnership is identifying the most suitable ways of sequestering CO_2 in Montana, Idaho and South Dakota. The Partnership is also developing a framework to validate and potentially deploy carbon sequestration technologies, study regional regulations, safety and environmental concerns and explore public acceptance issues. At the end of the first, two-year phase, the Partnership will recommend technologies for small-scale validation testing in a Phase II competition expected to begin in 2005.

Who can I contact to learn more about the Big Sky Carbon Sequestration Partnership?

Susan Capalbo, Big Sky Principal Investigator
Montana State University
scapalbo@montana.edu

Pamela Tomski, Big Sky Outreach Director
EnTech Strategies, LLC
ptomski@entech_strategies.com

Why Sequester CO_2?

Growing populations and economies worldwide will demand more energy. Meeting demand while balancing economic, social and environmental considerations require all energy technologies. Each must be harnessed as efficiently and cleanly as possible. Burning fossil fuels (coal, oil and natural gas) for transportation, electricity generation and industrial processes greenhouse gases (GHGs) into the atmosphere that may cause changes in regional and global climate. The most abundant GHG is CO_2. The challenge is transforming the world's massive, capital-intensive fossil energy system to achieve GHG stabilization without impacting the environment or the abilities of economies to grow and prosper. Because fossil fuels dominate energy production, carbon sequestration is critical to managing GHG emissions.

How is CO_2 Sequestered?

Terrestrial carbon sequestration relies on land management practices and technologies to remove CO_2 from the atmosphere through photosynthesis where it is stored in trees, plants and soils. Terrestrial sequestration reduces emissions while improving land and water quality thus making soils healthier, more productive and less susceptible to large-scale CO_2 releases. Also, CO_2 can be captured directly from large point sources such as power plants, oil refineries or large industrial facilities. The CO_2 can be transported in the Big Sky Region for injection into geologic formations including depleted oil and gas, saline formation(s), and deep unmineable coal seams.

What Do We Know?

Fossil fuels will remain the mainstay of energy production well into the 21st century. To stabilize and ultimately reduce concentrations of CO_2 it will be necessary to capture, separate, and store or reuse it.

Certain land management practices can reduce CO_2 emissions and store carbon in terrestrial ecosystems which improves land and water quality. Furthermore, CO_2 is routinely separated and captured as a by-product from industrial processes such as synthetic ammonia production, hydrogen production, and limestone calcination. The concept of geologic sequestration is based on the fact that carbon and CO_2 have been stored in naturally occurring geologic reservoirs throughout the world for thousands of years. CO_2 is also routinely injected into deplete oil fields to enhance recovery and there is an extensive pipeline network primarily in the U.S. that has been transporting CO_2 for decades. Also, geologic sequestration is currently being done. Since 1996 the Norwegian oil company, Statoil, has been reinjecting approximately one million tons per year of CO_2 that is stripped from its natural gas production into a thick saline formation beneath the North Sea floor. The amount being sequestered is equivalent to the output of a 150-megawatt coal-fired power plant. The formation is enormous -- to provide a sense of scale, it takes one hour to fly over the length of the formation, which is about as big as Norway. This, and other geologic formations located throughout the world, have potential to hold significant amounts of CO_2, safely and permanently.

What Needs to be Done?

Existing CO_2 capture technologies are energy intensive and not cost-effective. Research is underway to improve performance, reduce costs and develop novel capture technologies. Assuring the environmental acceptability and safety of CO_2 storage in geologic formations is a key issue and a major component of the research being done worldwide. Determining that CO_2 will be permanently stored in geologic formations is essential. Although much work is needed to better understand and characterize sequestration of CO_2 in geologic formations, researchers are building on the significant baseline of information and experience that exists. Furthermore, the U.S. Department of Energy is conducting an Environmental Impact Statement (EIS).

What Will the EIS Do?

The EIS will analyze the impacts of carbon sequestration technologies and potential future DOE demonstration activities programmatically, including CO_2 capture; sequestration (geological, terrestrial and oceanic); measurement, monitoring and verification; and "breakthrough" concepts. It will not directly evaluate specific field demonstration projects. The programmatic EIS will evaluate issues and impacts associated with regional carbon sequestration approaches, opportunities and needs. Findings from the EIS may be applicable to future site-specific projects within the DOE Carbon Sequestration Program for which separate National Environmental Policy Act (NEPA) documents would be prepared that tier from the programmatic EIS.

Why is DOE Holding This Meeting?

DOE is preparing a programmatic EIS pursuant to NEPA, the Council on Environmental Quality NEPA regulations (40 Code of Federal Regulations [CFR] parts 1500-1508) and DOE NEPA regulations (10 CFR part 1021), to access the potential environmental impacts from DOE's Carbon Sequestration Program. Acting Assistant Secretary for Fossil Energy Mark Maddox states, "We're offering this series of public meetings as a constructive step toward providing the foundation for future decisions about these options as they relate to future sequestration issues."

What Will DOE Do With the Public Comments?

Comments submitted will become part of the public record for the EIS process and will be considered by DOE as it develops the draft programmatic environmental impact statement. The draft programmatic EIS will be published in 2005. DOE will then solicit public comments on it at the same location as this year's meeting. The final programmatic EIS will be issued in 2006.

What if I Can't Attend the Public Meeting?

Written comments on the scope of the programmatic EIS can also be submitted by June 25, 2004 to:

Dr. Heino Beckert
NEPA Document Manager for Carbon Sequestration PEIS
U.S. Department of Energy
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
E-mail: heino.beckert@netl.doe.gov

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Big Sky CARBON SEQUESTRATION PARTNERSHIP