FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Partnership Name	Southwest Regional Partnership on Carbon Sequestration
Contacts: DOE/NETL Project Mgr.	Name / Organization / E-Mail William O'Dowd / NETL / William.ODowd@NETL.DOE.GOV
Principal Investigator	Brian McPherson / SWP / brian@nmt.edu
Field Test Information: Field Test Name	San Juan Basin, New Mexico: Enhanced Coalbed Methane-Sequestration Test
Test Location	Near Navajo City, New Mexico
Amount and Source of CO_2	Tons / Source 35,000 tons/year for 1 year; CO2 sourced from McElmo Dome, CO
Field Test Partners (Primary Sponsors)	ConocoPhillips
	KinderMorgan CO_2 Company, L.P.

Summary of Field Test Site and Operations

General Geology and Target Reservoirs:

The San Juan basin (SJB) is one of the top ranked basins in the world for CO_2 coalbed sequestration because it has: 1) advantageous geology and high methane content; 2) abundant anthropogenic CO_2 from nearby power plants, 3) low capital and operating costs; 4) well developed natural gas and CO_2 pipeline systems; and 4) local companies, e.g., ConocoPhillips, with CBM and ECBM expertise. ConocoPhillips has agreed to operate a project in collaboration with the SWP, specifically to examine ECBM efficacy with CO_2 sequestration. Because of its

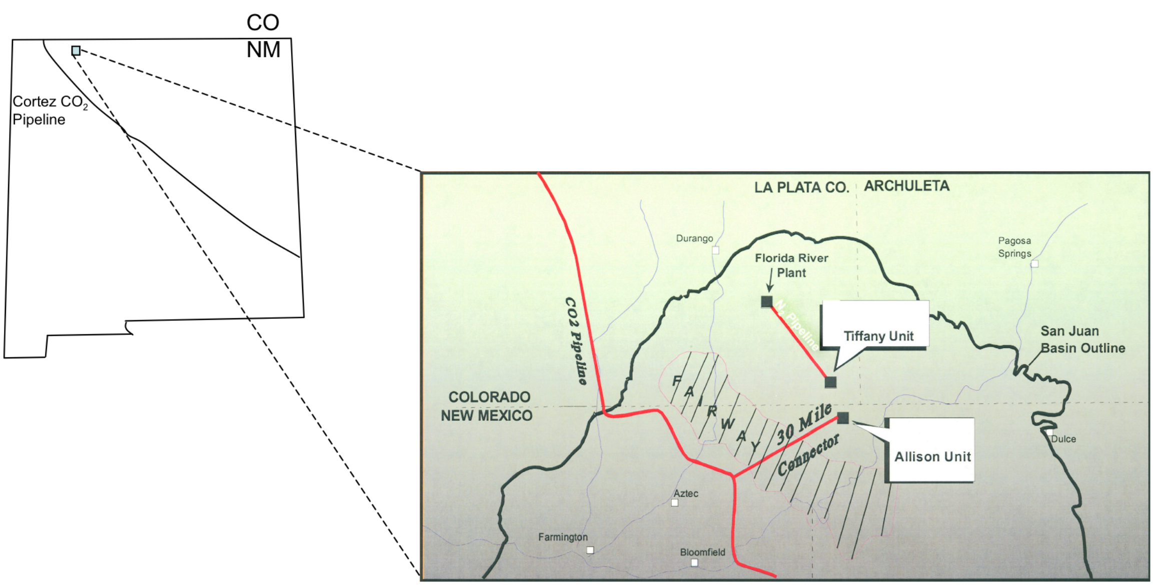

Figure 1: Location of SJB ECBM (Pump Canyon) demonstration test in the San Juan Basin, NM.

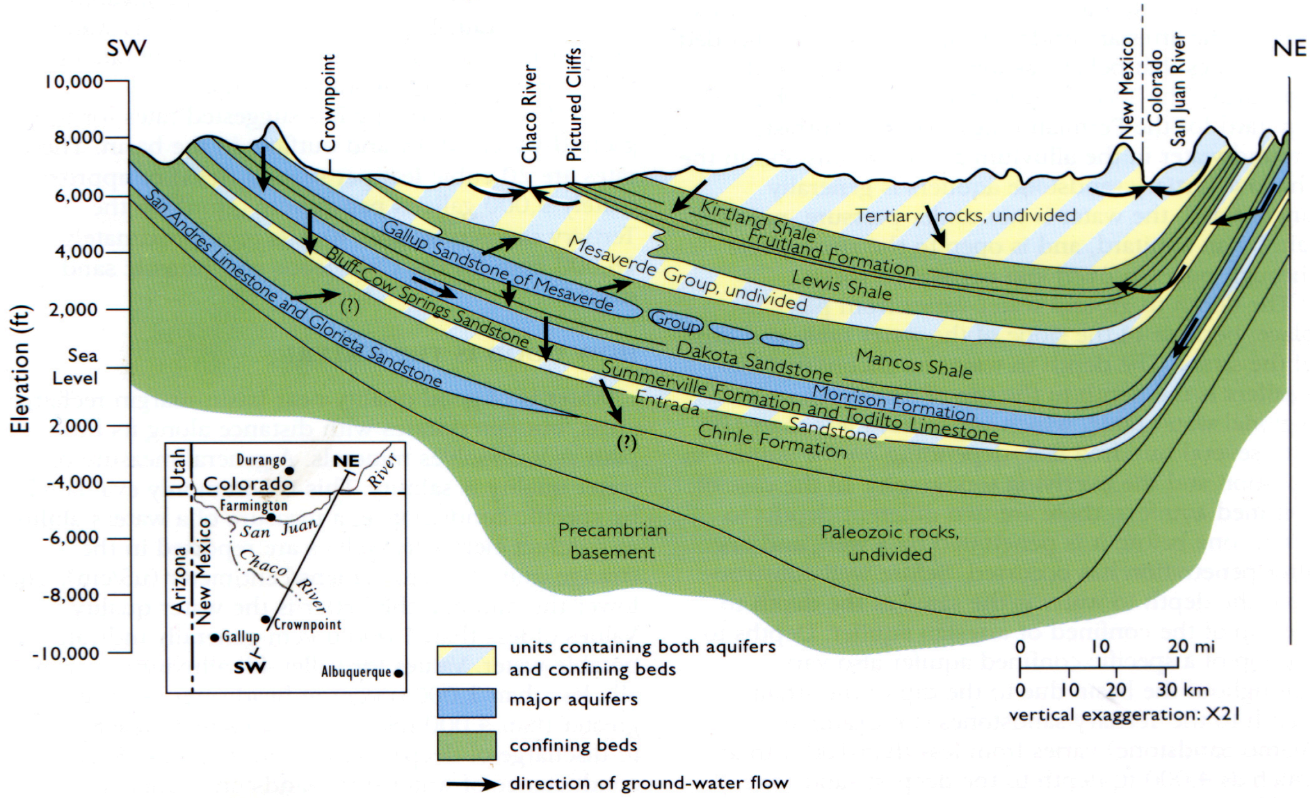

Figure 2. Generalized cross-section of San Juan basin, also showing large-scale hydrologic patterns. Adapted from Stone et al., “Hydrogeology and water resources of *San Juan* Basin, New Mexico,” Hydrologic Report - New Mexico Bureau of Mines and Mineral Resources, vol.6, 70 pp., 1983.

enormous coal resource, the San Juan offers a tremendous sequestration opportunity with value-added natural gas production. An extensive CO_2 infrastructure is already in place, making the area ready for future operations. In addition to the ECBM pilot test, a terrestrial pilot test will be conducted. ECBM operations are notorious for producing huge volumes of water. We propose to desalinate produced water from our ECBM pilot and use this water for irrigating stressed riparian areas near the injection site, forming a combined ECBM – terrestrial sequestration project. The U.S. Bureau of Land Management and ConocoPhillips are both interested in making beneficial and environmentally-friendly use of the produced water.

The coals in the SJB fairway area are of exceptionally high permeability—100s of millidarcies. Due to the tendency of coal to swell when in contact with CO_2, high initial coal permeability is required to maintain high CO_2 injection rates over time. Maintaining high injectivity is an important requirement for large-scale, low-cost CO_2 sequestration in coal, and demonstrating this is an important DOE carbon sequestration program goal (as stated in DOE’s 2004 Technology Roadmap and Program Plan). This demonstration represents an ideal opportunity to achieve that goal.

The injection site will consist of four CBM producing wells drilled on 80-acre spacing. The primary gas-producing horizons in this area are coal beds in the Upper Cretaceous Fruitland Formation. The coals, which occur at depths of approximately 3,000 feet, are about 75 feet thick split among three seams over a 175-foot gross interval. This area of the San Juan coalbed fairway has undergone significant CBM production, and reservoir pressures at the test site are less than100 psi. Coal matrix shrinkage is significant at these low pressures, contributing to the high coal permeabilities that exist there. In addition, CO_2 injection pressures will be low, eliminating any potential CO_2 compression needs for the pilot project.

Brief Summary of Target Reservoirs and Seals:

- **Producing Formations:** Fruitland Formation coals (Figure 2) are the primary sequestration test target reservoir.
- **Deepest fresh water aquifer**: Probably the deepest freshwater zone to consider is the Dakota sandstone.
- **Type of trap and reservoir geometry:** The Fruitland coals are capped structurally and stratigraphically by the Kirtland shale (Figure 2).
- **Potential leakage points**: The region of the San Juan Basin where the injection well is located contains no major tectonic elements. However, in outer sections of the basin, particularly the southern and eastern stretches, some fracture zones are evident. Additionally, the injection site is approximately 40 miles from the four corners platform, which is separated from the central basin by the hogback monocline. Extension fractures located in the greater Cuba Mesa area as well minor northwest trending faults. We suggest that none of these structural features will affect the sequestration test, but must be considered prior to longer-term geological sequestration.
- **Pay zone thickness:** The Fruitland Formation approaches 250' thickness in some areas.
- **Porosity and Permeability:** Porosity of the Fruitland is highly variable (<1 to over 20%), but permeability is generally hundreds of millidarcies in the area of the sequestration test.
- **Water saturation and water characteristics:** The coals are saturated with methane and/or groundwater of relatively low TDS in the area of the sequestration test.

Data Quality: Data in the immediate vicinity of our test site is fairly robust, given ConocoPhillips' previous analyses of the area. However, other operators own several nearby wells, and the SWP is negotiating with those operators to gain access to relevant data.

Surface Description and Land Use: Much of the land in the area is maintained by the U.S. Bureau of Land Management. Topography is fairly rugged, with little grass but many shrubs and small trees. The injection site is close to a riparian corridor that is rich with grass, although drought, grazing, and other activities has stressed the riparian areas.

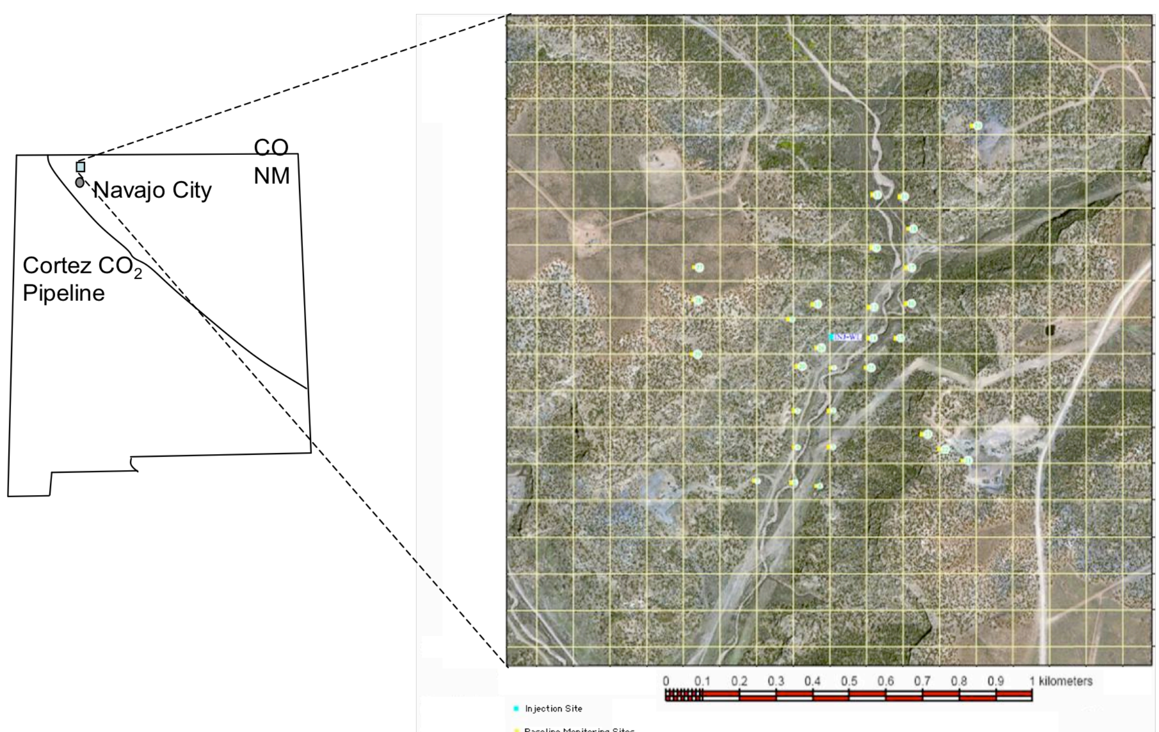

Figure 3: Surface image of injection site location of SJB ECBM (Pump Canyon) demonstration test in the San Juan Basin, NM.

Research Objectives

ECBM-Sequestration Testing: Among primary goals of the SWP is to evaluate coalbed methane production efficiency with concomitant CO_2 storage efficacy. Pilot CO_2 injection is scheduled to begin around July or August, 2007, and continue for one year. Plans include injection of about 75,000 tons CO_2 during that year as conditions permit. ConocoPhillips owns and operates the field site, and will drill the injection well for the pilot. This pilot, like the others planned, is intended to test a suite of MMV approaches tailored for its unique geology (coalbeds) and value-added benefit (methane production). Additional objectives include detailed risk assessment and mitigation plans, and to identify regulatory gaps for ECBM and CO_2 sequestration.

The SJB ECBM/CO_2 sequestration field test site is located in San Juan County, New Mexico, in the heart of the San Juan Basin (SJB) coalbed methane (CBM) fairway (Figures 1 and 3). The injection location, illustrated in Figure 3, is uniquely favorable for an ECBM/sequestration demonstration for several reasons. The results of the demonstration would be directly scalable to a large portion of the SJB for significant, low-cost sequestration. The SJB is a mature CBM play, and thus much of the infrastructure and services required to implement large-scale sequestration are already in place (e.g., wellbores, gathering and distribution systems, processing facilities, etc.). In addition, a well-established, reasonably-priced service capability to maintain and expand that infrastructure exists. Finally, and perhaps most importantly, the infrastructure to deliver CO_2 to the region exists – the Cortez pipeline that delivers (natural) CO_2 from McElmo Dome to West Texas passes directly through the SJB (Figure 1). If/when that pipeline begins transporting anthropogenic CO_2, the SJB will become a premier national sequestration site. Thus, the SJB represents an important near-term option for CO_2 sequestration.

Summary of Modeling and MMV Efforts

Table 1 below provides a summary of our ongoing and future monitoring activities for the San Juan Basin ECBM-sequestration testing. State-of-the-art reservoir models are being used for test design and engineering, and data from these monitoring activities are being used to parameterize these models. These models include coupling of multiphase CO2-groundwater flow, coal-swelling and rock deformation, and relevant chemical reactions.

Our first reservoir-modeling objective already underway is to determine optimum injection rates and potential breakthrough times to adjacent wells. The area's CBM performance history is being evaluated (matched) via reservoir simulation to calibrate unknown reservoir properties (e.g., relative permeability), which will become the primary basis for understanding subsequent pattern performance under CO_2 injection. Initial forecasting of pattern performance will be used to refine injection design and other operational plans (e.g., fine-tune injection rates, estimate optimum injection pressures, etc.).

Table 1. Measurement Technologies Employed at Aneth, Utah Test Site

Measurement technique	Measurement parameters	Applications
Introduced and natural tracers	- Travel time - Partitioning of CO_2 into brine or oil - Identification sources of CO_2	- Tracing movement of CO_2 - Quantifying solubility trapping - Tracing leakage
Water composition	- CO_2, HCO_3, CO_3^{2-} - Major ions - Trace elements - Salinity	- Quantifying solubility & mineral trapping - Quantifying CO_2-water-rock interactions - Detecting leakage into shallow groundwater aquifers
Subsurface pressure	- Formation pressure - Annulus pressure - Groundwater aquifer pressure	- Control of formation pressure below fracture gradient - Wellbore and injection tubing condition - Leakage out of the storage formation

Well logs	- Brine salinity - Sonic velocity - CO_2 saturation	- Tracking CO_2 movement in and above storage formation - Tracking migration of brine into shallow aquifers - Calibrating seismic velocities for 2D seismic surveys
Time-lapse 2-D seismic imaging	- P and S wave velocity - Reflection horizons - Seismic amplitude attenuation	- Tracking CO_2 movement in and above storage formation
Vertical seismic profiling	- P and S wave velocity - Reflection horizons - Seismic amplitude attenuation	- Detecting detailed distribution of CO_2 in the storage formation - Detection leakage through faults and fractures
Passive seismic monitoring	- Location, magnitude and source characteristics of seismic events	- Development of microfractures in formation or caprock - CO_2 migration pathways
Electrical techniques	- Formation conductivity	- Tracking movement of CO_2 in and above the storage formation - Detecting migration of brine into shallow aquifers
Time-lapse microgravity techniques	- Density changes caused by fluid displacement	- Detect CO_2 movement in or above storage formation - CO_2 mass balance in the subsurface
Visible and infrared imaging from satellite	- Hyperspectral imaging of land surface	- Detect vegetative stress
CO_2 land surface flux monitoring using flux chambers or eddycovariance	- CO_2 fluxes between the land surface and atmosphere Atmosphere	- Detect, locate and quantify CO_2 releases
Soil gas sampling	- Soil gas composition Isotopic analysis of CO_2	- Detect elevated levels of CO_2 - Identify source of elevated soil gas CO_2 - Evaluate ecosystem impacts
Land surface deformation	- Tiltmeters - Vertical and horizontal displacement using interferometry and GPS	- Detect geomechanical effects on storage formation and caprock - Locate CO_2 migration pathways

Source of Headings: IPCC Special Report on Carbon Dioxide Capture and Storage

Accomplishments to Date

- Baseline surface fluxes measured
- Baseline reservoir groundwater (brine) compositions assessed
- 3-D reservoir model grids assembled and simulations underway.
- Tiltmeter array surveyed and being installed.

Summary of Target Sink Storage Opportunities and Benefits to the Region

The San Juan Basin has been previously assessed by Advanced Resources International (ARI) under the DOE-sponsored Coal-Seq project as one of the nation's top coal basins for sequestration in terms of potential storage capacity (12 Gt of CO_2, 12% of U.S. total), ECBM potential (16 TCF, 10% of U.S. total), and potential cost of storage (at a predicted net profit of $4-8/ton of CO_2).

In addition to gaining a better understanding of ECBM and sequestration potential, another benefit to the region is evaluation and application of new, alternative, beneficial use of produced water: irrigation of stressed riparian areas will not only take up additional carbon, but will also help restore the local ecosystems in general.

Cost:	Field Project Key Dates:
Total Field Project Cost: Approximately $5.5M	**Baseline Completed: May, 2007**
DOE Share: Approximately $4.4M or 80%	**Drilling Operations Begin: December, 2007**
Non-Doe Share: Approximately $1.1M or 20%	**Injection Operations Begin: December, 2007**
	MMV Events: July, 2007

Field Test Schedule and Milestones

Major field operations, including well-drilling, pipeline planning, reservoir engineering and baseline MMV operations, began in winter and spring of 2006. Safety training, initial reservoir model grids, and other essential SWP activities also began during this past year. First injection is scheduled for July, 2007. A general summary of the SWP's schedule for the Utah project is provided in the Gantt chart below.