



the **ENERGY** lab

PROJECT FACTS  
Carbon Sequestration

## Southwest Regional Partnership for Carbon Sequestration—Validation Phase

### Background

The U.S. Department of Energy (DOE) has selected seven partnerships, through its Regional Carbon Sequestration Partnership (RCSP) initiative, to determine the best approaches for capturing and permanently storing carbon dioxide (CO<sub>2</sub>), a greenhouse gas (GHG) which can contribute to global climate change. The RCSPs are made up of state and local agencies, coal companies, oil and gas companies, electric utilities, universities, private companies, and nonprofit organizations that form the core of a nationwide network helping to establish the most suitable technologies, regulation, and infrastructure needs for carbon sequestration. The partnerships include more than 350 organizations, spanning 43 states and four Canadian provinces. The RCSPs are developing the framework needed to validate and deploy carbon sequestration technologies. The RCSPs will determine which of the numerous sequestration approaches are best suited for their specific regions of the country and identify regulatory and infrastructure requirements that will be needed should policy and economics indicate that sequestration be deployed on a wide scale. The RCSP initiative is being implemented in three phases. The Characterization Phase began in September 2003 with the seven partnerships working to develop the necessary framework to validate and potentially deploy carbon sequestration technologies. The Validation Phase of the RCSP effort (2005–2009) is focused on evaluating promising CO<sub>2</sub> sequestration opportunities through a series of field tests in the seven partnership regions. Presently, activities in the Development Phase (2008–2017) are proceeding and will continue the validation process to determine that CO<sub>2</sub> capture, transportation, injection, and storage can be achieved safely, permanently, and economically at a large scale. These tests will promote understanding of injectivity, capacity, and storability of CO<sub>2</sub> in the various geologic formations identified by the partnerships. Results and assessments from these efforts will assist commercialization efforts for future sequestration projects in North America.

### Description

The Southwest Regional Partnership for Carbon Sequestration (SWP), led by the New Mexico Institute of Mining and Technology in Socorro, New Mexico includes the states of Colorado, Oklahoma, New Mexico, and Utah and portions of Arizona, Kansas, Texas, and Wyoming. The SWP is conducting five field tests—three geologic and two terrestrial—all at various stages of planning and execution, and each designed to validate the most promising carbon sequestration technologies and infrastructure concepts. The field tests represent a variety of carbon sink targets, including enhanced oil recovery (EOR) with carbon sequestration, enhanced coalbed methane (ECBM) production with carbon sequestration, and geologic sequestration tests combined with terrestrial tests.

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U.S. DEPARTMENT OF  
**ENERGY**

## PARTNERS

Advanced Resources International (ARI)  
Applied Sciences Lab  
Arizona Geological Survey  
Arizona State University  
Blue Source, LLC  
Center for Energy & Economic Development (CEED)  
Chevron  
Colorado Geological Survey  
Colorado School of Mines  
Colorado State University  
ConocoPhillips  
Dine College  
Electric Power Research Institute (EPRI)  
Gas Technology Institute (GTI)  
Intermountain Power Agency  
Interstate Oil and Gas Compact Commission (IOGCC)  
Kinder Morgan CO<sub>2</sub> Company, L.P.  
Los Alamos National Laboratory  
Navajo Nation  
Navajo Nation Oil and Gas Company  
New Mexico Bureau of Geology  
New Mexico Environmental Department  
New Mexico Institute of Mining and Technology  
New Mexico Oil and Gas Association (NMOGA)  
New Mexico Oil Conservation Division  
New Mexico State University  
Occidental Permian Ltd.  
Oklahoma Gas and Electric  
Oklahoma Geological Survey  
Oklahoma State University  
PacifiCorp  
NM Petroleum Recovery Research Center (PRRC)  
Public Service Company of New Mexico (PNM)  
Resolute Natural Resources Company  
Sandia National Laboratories  
Southern Cal Edison Electric Service  
Texas A&M University  
Texas Bureau of Economic Geology  
Tucson Electric Power Company

In the Southwest region, over 95 percent of anthropogenic CO<sub>2</sub> emissions result from fossil fuel combustion, with about half of these emissions from power plants. Geologic storage options include coal seams (approximately 1.1 billion tons [1 billion metric tons] of minimum storage potential), natural gas and depleted and marginal oil fields (25 billion tons [23 billion metric tons] minimum storage potential), and deep saline formations (102 billion tons [93 billion metric tons] of minimum storage potential). One option the SWP is exploring is the viability of supplanting the CO<sub>2</sub> currently produced from natural CO<sub>2</sub> reservoirs, used for enhanced oil and natural gas recovery, with anthropogenic CO<sub>2</sub> from power plants. The presence of CO<sub>2</sub> pipelines that bridge CO<sub>2</sub> sources and potential CO<sub>2</sub> sinks improve the viability of this possibility. Although terrestrial CO<sub>2</sub> sequestration appears to be a viable alternative in several parts of the Southwest region, low rainfall in some areas decreases the relative terrestrial storage capacity, limiting the applications of this option.

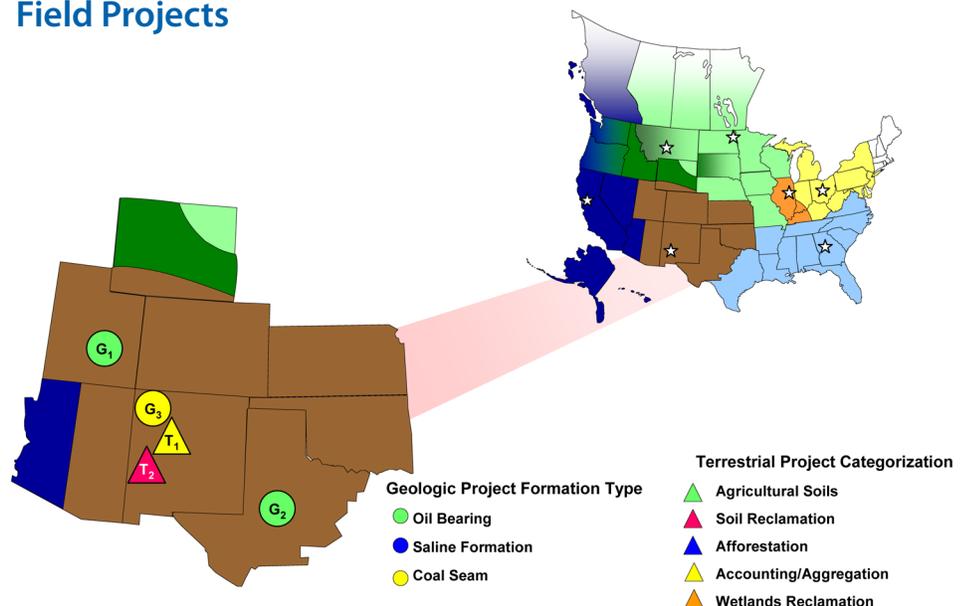
## Primary Project Goal

The SWP's primary project goal is to develop an optimum sequestration strategy for the partnership, subject to the constraints unique to the region (such as water availability), identify the available technologies on which to base the strategy, determine technology gaps, and perform field tests of sequestration options.

## Objectives

- Conduct multiple field pilot tests to validate the most promising sequestration technologies and infrastructure concepts in different parts of the region, including three geologic pilot tests and two terrestrial pilot programs.
- Develop risk mitigation procedures for the sequestration tests.
- Optimize monitoring, validation, and accounting (MVA) protocols for each test.
- Conduct effective outreach and communication to stakeholders and the general public.

## Field Projects



*Southwest Regional Partnership for Carbon Sequestration Validation Phase Field Tests*

## Geologic Sequestration Opportunities

The Southwest region is rich in geologic sinks, including depleted oil and natural gas fields, saline formations, and coal beds. EOR using CO<sub>2</sub> has been conducted in the region for over 30 years. Several hundred miles of CO<sub>2</sub> pipelines through the region provide access to CO<sub>2</sub> near many candidate project sites. The SWP pilot-scale injection tests are being deployed in two types of geologic sinks, piggy-backing upon commercial projects.

### Paradox Basin, Utah: Aneth EOR-Sequestration Test (G1)

Since August 2007, the SWP has been testing EOR combined with sequestration by injecting a minimum of 150,000 tons (136,000 metric tons) of CO<sub>2</sub> per year into the Desert Creek and Ismay producing zone, approximately 5,800 feet deep, in the Aneth Oil Field in San Juan County near Bluff, Utah. The injection schedule is expected to run for two years with post-injection monitoring to follow. The CO<sub>2</sub> for this project is sourced from the McElmo Dome, a natural CO<sub>2</sub> reservoir located in southwestern Colorado.

#### Accomplishment Highlights:

- Baseline and repeat surface fluxes measured.
- Baseline reservoir groundwater (brine) compositions assessed.
- Three-dimensional (3-D) reservoir model grids assembled, and initial simulations conducted for capacity and migration analyses.
- Surface and subsurface geological maps and cross-sections refined through new mapping.
- Injection began in August 2007.
- Reservoir tracer testing began in July 2007; analyses are ongoing.
- Baseline and repeat vertical seismic profiles conducted.

### Permian Basin, Texas: SACROC EOR Sequestration Test (G2)

This test includes a post-audit modeling analysis of injected CO<sub>2</sub> for EOR over the last 30 years at the SACROC Unit in the Permian Basin of Texas, in addition to intense MVA analyses of ongoing CO<sub>2</sub> injection at SACROC. Results will be used by Kinder Morgan to define an optimized commercial approach to EOR with sequestration in the Claytonville field, a nearby field with similar geology that has not yet been subjected to CO<sub>2</sub> injection. Kinder Morgan will begin CO<sub>2</sub> injection at Claytonville in 2010. The SACROC pilot represents an opportunity for making CO<sub>2</sub> storage history—matching in tandem with large-scale MVA operations during injection of between 900,000 and 1.5 million tons (816,300–1.36 billion metric tons) of CO<sub>2</sub>. The target formations are the Cisco and Canyon Formations within the Horseshoe Atoll Play and the Pennsylvanian Reef/Bank Play.

#### Accomplishment Highlights:

- Baseline surface fluxes measured.
- Baseline reservoir groundwater (brine) compositions assessed.
- 3-D reservoir model grids assembled.
- 3-D reservoir simulations successfully run, using models that are fully parameterized with multiphase flow of oil, CO<sub>2</sub>, brine, and reactive chemistry.
- Surface and subsurface geologic maps and cross-sections refined through new mapping techniques.
- 3-D reflection seismic survey completed.
- 2-D vertical seismic profile (VSP) completed.
- CO<sub>2</sub> injection started in first two wells in September 2008 and second two well injection in November 2008.

## PARTNERS

U.S. Department of Agriculture  
University of Oklahoma  
University of Utah  
Utah Automated Geographic Reference Center (AGRC)  
Utah Division of Air Quality  
Utah Division of Oil, Gas, & Mining  
Utah Energy Office  
Utah Geological Survey  
Utah State University  
Waste-Management Education & Research Consortium (WERC)  
Western Governors' Association  
Xcel Energy  
Yates Petroleum Corporation

## COST

### Total Project Value

\$17,488, 733

### DOE/Non-DOE Share

\$12,885,933 / 4,602,800

## San Juan Basin, New Mexico: Enhanced Coalbed Methane (ECBM) Sequestration Test (G3)

The San Juan Basin pilot test will examine ECBM efficacy and degree of CO<sub>2</sub> sequestration by injecting 35,000 tons (31,700 metric tons) of CO<sub>2</sub> sourced from the McElmo Dome into the coals of the Upper Cretaceous Fruitland formation. The project proposes to desalinate produced water from the ECBM pilot and use the water for irrigating a riparian restoration project, forming a combined ECBM/terrestrial sequestration project. The test site is at the San Juan Basin Coal Fairway, near Navajo City, New Mexico.

### **Accomplishment Highlights:**

- Baseline surface fluxes measured with follow-up surveys on-going.
- Baseline reservoir groundwater (brine) compositions assessed.
- 3-D reservoir model grids assembled and simulations underway.
- Tiltmeter array installed.
- Desalination testing permits acquired.
- Baseline vertical seismic profile and well logs completed.
- Injection operations began July 2008.

## Terrestrial Sequestration Opportunities

Terrestrial carbon capacity in the Southwest region is limited by low average annual precipitation and yearly variability in precipitation. Even in systems managed for carbon storage, wet years followed by a series of dry years may result in a net carbon flux out of the system. Opportunity to increase carbon storage on rangelands is limited because most areas are at a relatively stable equilibrium given land use history and management. Much of the desert grassland and shrub land areas with less than 12 inches of annual precipitation are subject to loss of cover and exposure to wind and water erosion. Retaining soil carbon levels in these ecosystems will require active restoration practices that are challenging, given current technologies. Two demonstration projects are proposed.

### **Southwest Regional Terrestrial Pilot Test (T1)**

The terrestrial pilot test will develop a carbon reporting and monitoring system that functions consistently across hierarchical scales and is compatible with the existing technology underlying the DOE's Energy Information Administration Voluntary Reporting of Greenhouse Gases (1605b) Program. Within this system, the project will achieve the following: (1) develop improved technologies and systems for direct measurement of soil and vegetation carbon at reference sites selected within the region; (2) develop remote sensing and classification protocols to improve mesoscale (km<sup>2</sup>) soil and vegetation carbon estimates; (3) construct ecological process (State and Transition) models that reflect soil/vegetation changes resulting from current land use and land use associated with implementation of programs to sequester carbon or reduce carbon losses; and (4) develop a regional inventory and decision support tool. The value-added products of the test will be new carbon credits and increased land productivity.

### **Accomplishment Highlights:**

- Applied pattern recognition technology to remotely sensed imagery to classify rangeland plant communities.
- Using model simulations, identified soil/vegetation combinations that have high uncertainty levels.
- Acquired soils for testing and model calibration.
- Completed initial tests of laser-induced breakdown spectroscopy (LIBS) as a laboratory and field base measurement technology.
- Collected and analyzed soils from arid rangelands which show an approximate decrease by 20 percent in carbon levels with degradation of the vegetation characterized by loss of grasses and increase in shrubs.
- Completed state and transition models for several common plant communities (pinon-juniper, creosote, mesquite, desert grassland) in the region and developed remote sensing protocols to identify different states on large areas.

### **Terrestrial Riparian Restoration Project (T2)**

This project proposes to desalinate produced water from the San Juan Basin ECBM pilot test and use the water for irrigating a riparian restoration project, forming a combined ECBM/terrestrial sequestration project. The test site will be the San Juan Basin Coal Fairway near Navajo City, New Mexico and will involve such value-added products as new carbon credits, improved water quality, and improved ecological conditions.

### **Accomplishment Highlights:**

- This project is being conducted in tandem with the SWP's ECBM project in the San Juan Basin.
- Applied treated water to existing species and common soils used for restoration in order to identify the effects on plant growth and reproduction.

## Benefits

This project will benefit the United States by providing a comprehensive assessment of the sources and potential sinks for CO<sub>2</sub> in the Southwest region. This data can be integrated with the data from other partnerships to provide a database covering the entire nation. The data generated by the field tests will provide information to evaluate potential commercial-scale sequestration projects in the Southwest. Some value-added benefits of the project include enhanced recovery of oil, natural gas, and coalbed methane. Methane is adsorbed in coals, and CO<sub>2</sub> can replace the methane and release it for recovery. Part of the value-added benefits for oil, natural gas, and methane recovery is that some of the cost of CO<sub>2</sub> storage is mitigated by the revenue from the sale of the recovered hydrocarbons. Currently, all such enhanced resource recovery operations use CO<sub>2</sub> drawn from natural CO<sub>2</sub> reservoirs. If all enhanced recovery operations in the southwestern United States were to use power plant-generated CO<sub>2</sub> rather than natural CO<sub>2</sub>, it is estimated that the region could achieve at least a 10 percent reduction in GHG intensity. An additional value-added benefit for the region is a potential increase in carbon credits.