

FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST (Rev. 10-28-09)

Partnership Name	West Coast Regional Carbon Sequestration Partnership (WESTCARB)		
Contacts: DOE/NETL Project Mgr.	Name Dawn Deel	Organization Carbon Sequestration Program	E-Mail Dawn.Deel@NETL.DOE.gov
Principal Investigator	Larry R. Myer	Lawrence Berkeley National Laboratory	LRMyer@lbl.gov
Field Test Information: Field Test Name	Arizona Utilities CO ₂ Storage Pilot Test		
Test Location	Northeastern Arizona		
Amount and Source of CO ₂	Tons: N/A	Source: N/A	
Field Test Partners (Primary Sponsors)	Arizona Electric Power Cooperative, Arizona Public Service Company, Peabody Energy, Salt River Project, Tucson Electric Power Company		
Summary of Field Test Site and Operations:			
<p>The Arizona Utilities CO₂ Storage Pilot Project is organized into three distinct phases:</p> <ul style="list-style-type: none"> <p>• Phase 1. Pre-pilot planning, geologic characterization, site selection, and public outreach. The objective of the project's initial phase was to develop a better understanding of the geologic and hydrologic characteristics of saline formations in the Colorado Plateau region of northeastern Arizona and to build support for a CO₂ storage pilot test within the surrounding communities. The scope of work for this phase consisted of reviewing available data on the area's sedimentary rock formations and groundwater salinity, identifying and screening sites for a CO₂ storage test, and reviewing regional data to confirm expectations of the large CO₂ storage potential of the Colorado Plateau in Arizona. Five candidate project sites were evaluated, and a site on Arizona Public Service Company (APS) land, near the coal-fired Cholla power plant, was chosen. WESTCARB and Arizona utility representatives (the project's industry partners) then met with community leaders, local businesses, citizens, news media, and other interested stakeholders to provide project information and to gather feedback. NEPA documentation for the project was developed and submitted.</p> <p>• Phase 2. Site characterization, detailed pilot project planning, permitting, well drilling, and testing at Cholla. The objective of the project's second phase was to obtain the necessary permits and to drill a well to collect preliminary site-specific data to determine if the site was suitable for CO₂ injection. [Favorable results would have then led to a third phase consisting of CO₂ injection and post-injection monitoring.]</p> <p>To accomplish the objectives of this phase, WESTCARB researchers analyzed data from nearby boreholes and associated water samples, developed hydrogeologic models and conducted computer simulations of CO₂ injection, formulated a field test plan, developed a well drilling plan and casing design, engaged regulators regarding CO₂ injection permit requirements, prepared and submitted the necessary permit applications for drilling and CO₂ injection, drilled a well to a depth of approximately 3850 feet (to "basement" in this</p> 			

area), extracted formation fluid samples from the target formations (Naco and Martin) to ascertain salinity, conducted a comprehensive set of well logs and drill stem tests to estimate porosity and permeability, and held public meetings in Holbrook, AZ, the largest nearby community.

Figure 1 shows the observed geologic column as determined by drilling at the test site. Researchers found very saline waters and good seal formations, as expected. However, the drill stem tests and well logs did not indicate the expected permeability in the target formations (which had shown desirable properties in other wells in the area). Figure 2 depicts WESTCARB researchers reviewing the well logs with WESTCARB partners.

Without a finding of sufficient permeability in a formation capable of supporting commercial-scale supercritical CO₂ storage, researchers prudently decided not to attempt CO₂ injection at the Cholla well site, and the project's third phase was redefined. Findings were shared with the surrounding communities via local media and the WESTCARB website.

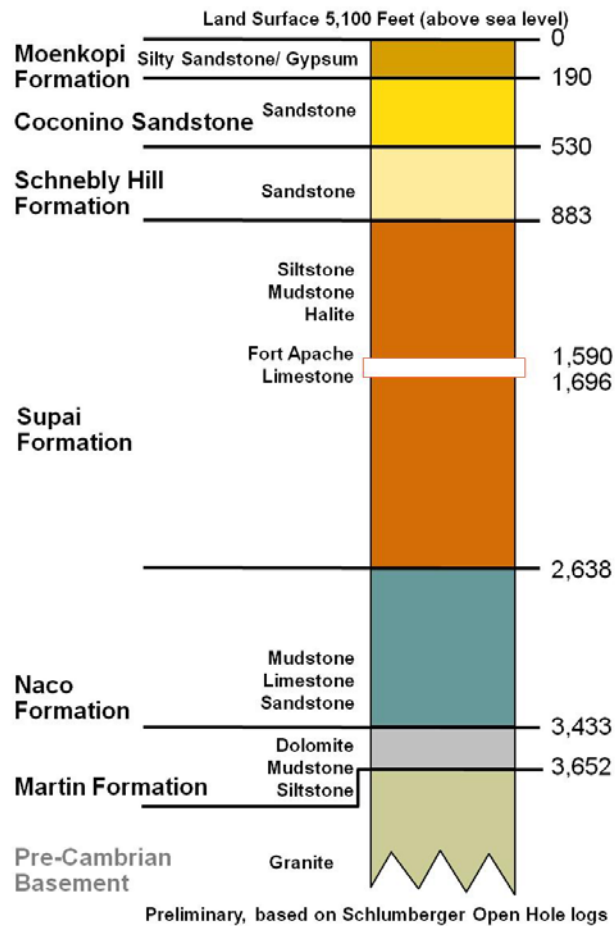


Figure 1. Schematic showing observed subsurface lithology in the test well near the Cholla power plant, west of Holbrook, Arizona. The Devonian age Martin Formation was the target storage formation, but it was found to have insufficient permeability at this location.



Figure 2. WESTCARB researchers review well log data with WESTCARB partners as part of a tour of the Cholla well site.

- **Phase 3. Site characterization, detailed pilot project planning, permitting, well drilling, and testing at Cholla.** The finding of insufficient permeability at the Cholla site has led WESTCARB researchers to redirect the pilot project's third phase to drilling and characterization of an alternate site in the Colorado Plateau of northeastern Arizona. Relative to areas with oil and gas production, there are few deep wells in Colorado Plateau sedimentary formations, yet the area hosts one of the West's largest concentration of baseload coal-fired power plants, making it an ideal location for future CO₂ capture and storage projects. Accordingly, there is great value in collecting reliable data on subsurface rock and fluid properties for the area's regionally extensive saline formations.

Research Objectives:

The Arizona Utilities CO₂ Storage Pilot is part of a broader North American research effort to validate scientists' consensus opinion that geologic carbon sequestration can mitigate adverse climate change impacts by safely and permanently keeping CO₂—a greenhouse gas—away from the atmosphere. In addition, the Arizona Utilities CO₂ Storage Pilot has three specific objectives:

1. Demonstrate the safety and feasibility of CO₂ injection and storage in saline formations in the vast Colorado Plateau region of northeastern Arizona
2. Demonstrate and test methods for monitoring CO₂ storage projects in consolidated sandstone, shale, and carbonate fields

3. Gain experience with regulatory permitting and public outreach associated with geologic storage of CO₂ in a saline formation in Arizona

This pilot will investigate CO₂ storage capability in saline formations in the Colorado Plateau region in northeastern Arizona, which underlies four coal-fired power plants: Navajo, Coronado, and Springerville, which are operated by Salt River Project, and Cholla, which is operated by APS. The magnitude of the annual CO₂ emissions in this area, the large storage potential of the saline formations of the Colorado Plateau (as well as the Black Mesa Basin), and the high degree of interest by local utility operators make this an outstanding opportunity for assessing geologic storage options associated with large sources of CO₂ in the southwestern United States.

Summary of Modeling and Simulation Efforts:

Preliminary computer simulations were conducted by Lawrence Berkeley National Laboratory (LBNL) using TOUGH2/EOS7C to estimate the size, shape, and location of CO₂ following injection of 2000 tons into the target formation, and any pressure increase in formation fluids associated with the injection. For a set of assumptions that “bounded” expected results, simulations for the Cholla site suggested:

- If permeability had been high and uniform in the reservoir formation, the injected CO₂ could have risen up to 180 feet above the injection location (approximately 3500 feet deep), but would have likely stabilized before reaching the Supai Formation, the seal.
- If horizontal permeability had been high and vertical permeability had been low, the injected CO₂ might have extended 250 feet horizontally from the well before stabilizing. To allow for a margin of error, a value of 400 feet was used in the permit application.
- With injection pressure at the well controlled to prevent fracture of the reservoir formation, the maximum pressure increase at a distance of 400 feet from the well was modeled to be just 2.2% above the background pressure.

Upon identification of one or more alternate sites by the project team, LBNL researchers will revise their geologic models and run new simulations of CO₂ injection in Colorado Plateau saline formations.

Accomplishments to Date:

Progress on the pilot project proceeded according to plan through downhole testing at the Cholla site. In particular, the following activities were accomplished:

- Five industry partners—Salt River Project, Arizona Public Service, Tucson Electric Power, Arizona Electric Power Cooperative, and Peabody Energy—joined together to pledge more than \$1.1 million in financial support for the WESTCARB pilot project.
- WESTCARB engaged experienced Arizona geologists to assist with site selection and characterization. Favorable geology with very saline groundwater was identified near Holbrook, Arizona. APS offered to host the pilot test on its property just west of Holbrook, near the Cholla power plant.
- Public meetings were held in Holbrook in August 2007 and November 2008 to inform the community of the proposed project and invite their questions and involvement. WESTCARB personnel were interviewed by local news reporters on multiple occasions in 2008 and 2009.

- Business and community leaders in the greater Holbrook area embraced the pilot concept and were supportive of the project. The Navajo County Board of Supervisors and North Arizona Council of Governments both issued statements of endorsement.
- The project team identified all necessary state and federal permits for well drilling and CO₂ injection, and the site owner, APS, secured the permits from the responsible agencies.
- WESTCARB received NEPA clearance for the project from DOE's NEPA Examiner.
- APS prepared the site for field activities by grading access roads and a drilling pad area, running power lines to the site, and establishing work procedures to assure safety and environmental protection.
- WESTCARB's technical project site manager oversaw drilling of a 3800-foot oil and gas type well at the site along with associated mudlogging analyses, wireline logging, core sample collection, and drill stem tests (of formation permeability). A "blog style" section of the WESTCARB website provided daily updates during drilling. A link to the WESTCARB webpages by the Arizona Geological Survey's website broadened public awareness and education.
- Site tours were held for WESTCARB partners and representatives of the Hopi tribe.
- Well closure plans were established.

Summarize Target Sink Storage Opportunities and Benefits to the Region:

Four coal-fired power plants in the Colorado Plateau region of Arizona generate about 40 million tons of CO₂ each year. Growing electricity demand could result in the development of new generating units and additional sources of CO₂. The geologic setting of northeastern Arizona provides thick (up to 10,000 feet) sedimentary sequences with simple, near-horizontal stratigraphy and few faults. Multiple candidate storage reservoirs and overlying seal units exist in the area. This project is helping assess the CO₂ storage potential for high-salinity sandstone and/or carbonate formations representative of the northeastern Arizona region.

Cost:

Total Field Project Cost: \$5,686,856

DOE Share: \$ 4,579,470 (80.5%)

Non-DOE Share: \$1,107,386 (19.5%)

Field Project Key Dates:

Receipt of Permits: 11/08 to 3/09

Drilling at Cholla Site: 7/09 to 8/09

Testing and Data Analysis at Cholla: 8/09 to 9/09

Alternate Site/Characterization Program Selection: 9/09 to 11/09

Alternate Site Drilling, Testing, and Data Analysis: TBD

Field Test Schedule and Milestones (Gantt Chart):

ARIZONA UTILITIES CO₂ STORAGE PILOT

