


WEST
COAST
REGIONAL
CARBON
SEQUESTRATION
PARTNERSHIP
westcarb.org




WESTCARB Annual Business Meeting

Arizona Utilities CO₂ Storage Pilot

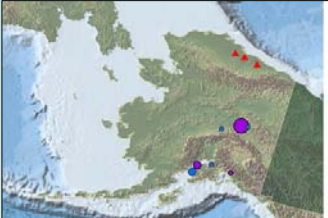
John Henry Beyer, Ph.D.
WESTCARB Program Manager, Geophysicist
510-486-7954, jhbeyer@lbl.gov

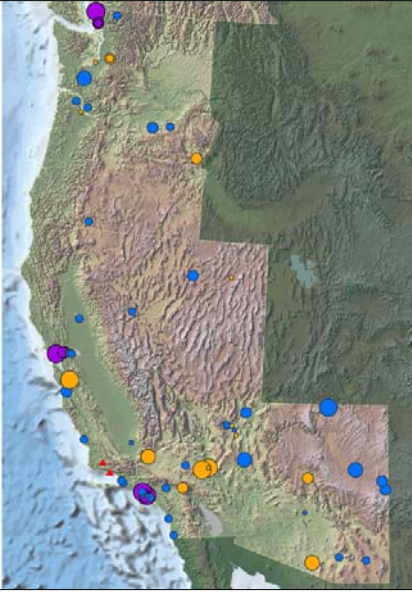
Lawrence Berkeley National Laboratory
Earth Sciences Division, MS 90-1116
Berkeley, CA 94720

Anchorage, Alaska
October 1, 2008

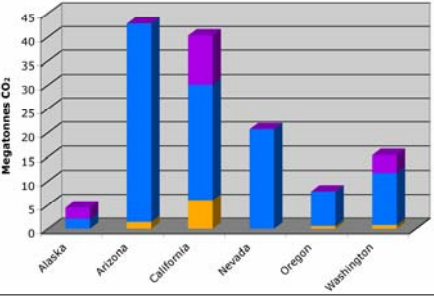



WESTCARB Region Has Major CO₂ Point Sources







**WESTCARB Region
Large Point-Source CO₂ Emissions
2002 data**




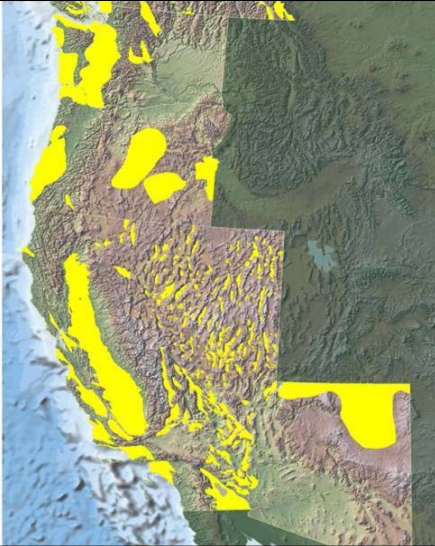
- Oil Refineries
- Power Plants
- Cement and Lime


State	Power Plants (Blue)	Oil Refineries (Purple)	Cement and Lime (Yellow)	Total
Alaska	~4	~1	~0	~5
Arizona	~38	~2	~0	~40
California	~25	~15	~5	~45
Nevada	~22	~2	~0	~24
Oregon	~8	~0	~0	~8
Washington	~10	~7	~0	~17

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WESTCARB region has many deep saline formations – candidates for CO₂ storage





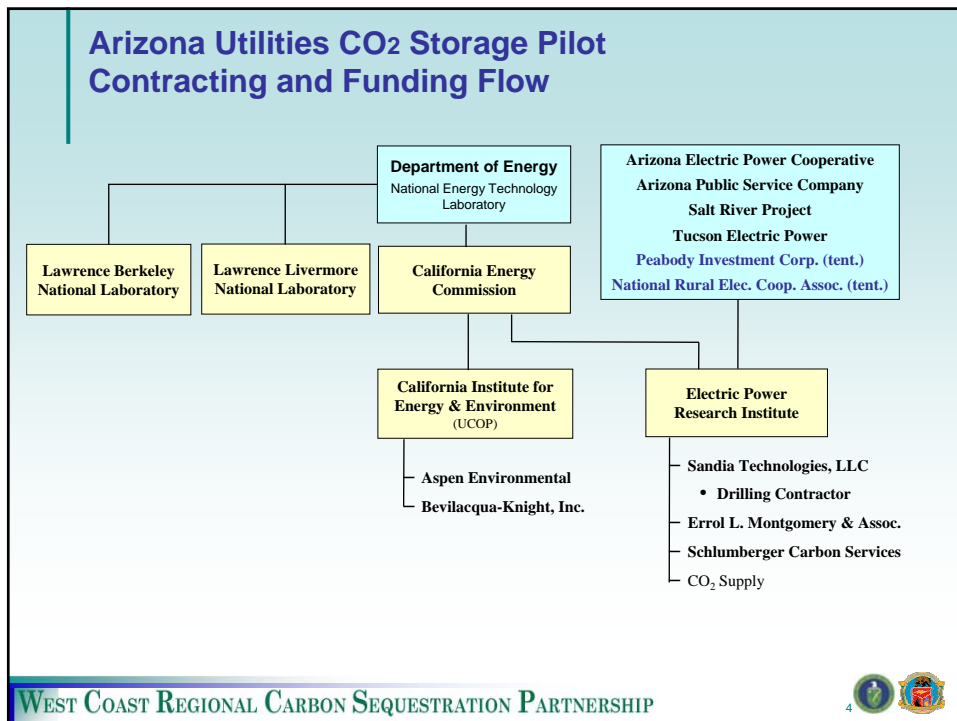
 **Deep Saline Formations**

WESTCARB also created GIS layers for oil/gas fields and deep coal basins

Source: *DOE Carbon Sequestration Atlas of the United States and Canada*

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Arizona Utilities CO₂ Storage Pilot project partners







A Unisource Energy Company




- Arizona Public Service Company
- Salt River Project
- Tucson Electric Power
- Arizona Electric Power Cooperative
- National Rural Electric Coop Assoc. (tent.)
- Peabody Investment Corp. (tent.)
- Electric Power Research Institute (and members)
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- California Energy Commission
- U.S. Department of Energy

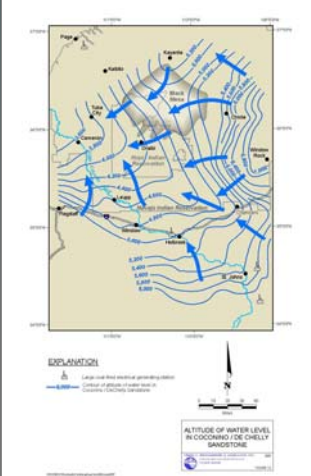




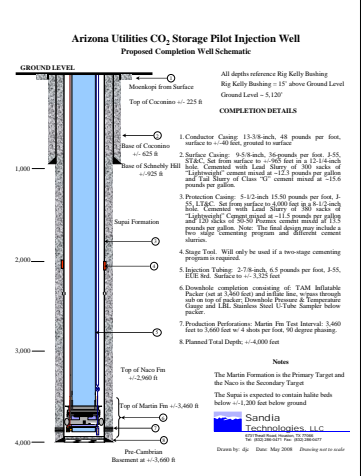
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EPRI - Site Selection and Project Support

Errol L. Montgomery & Assoc.

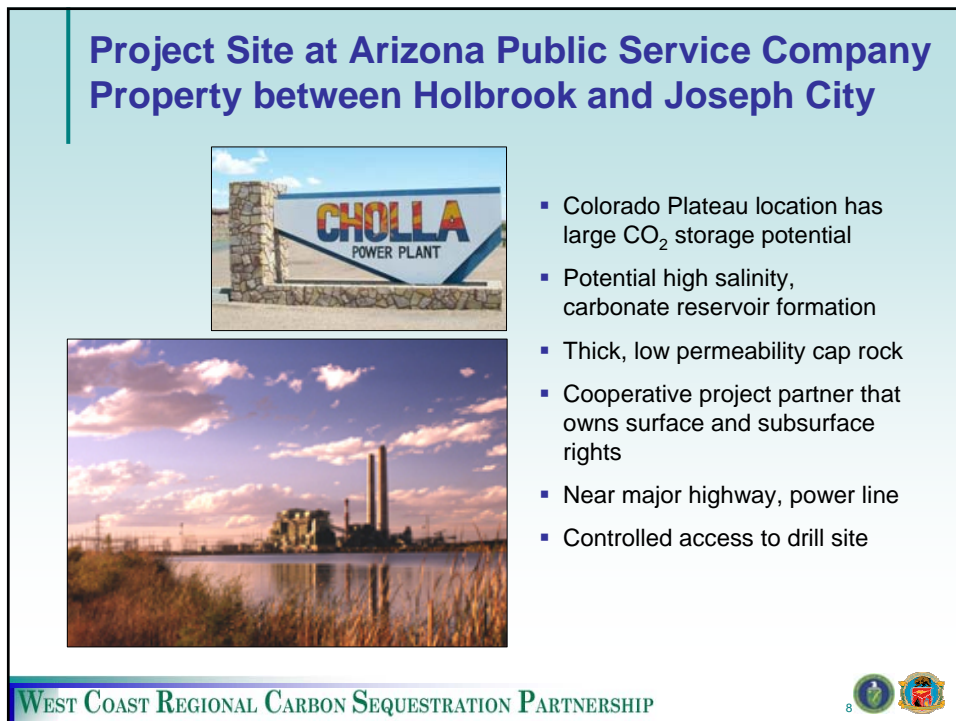
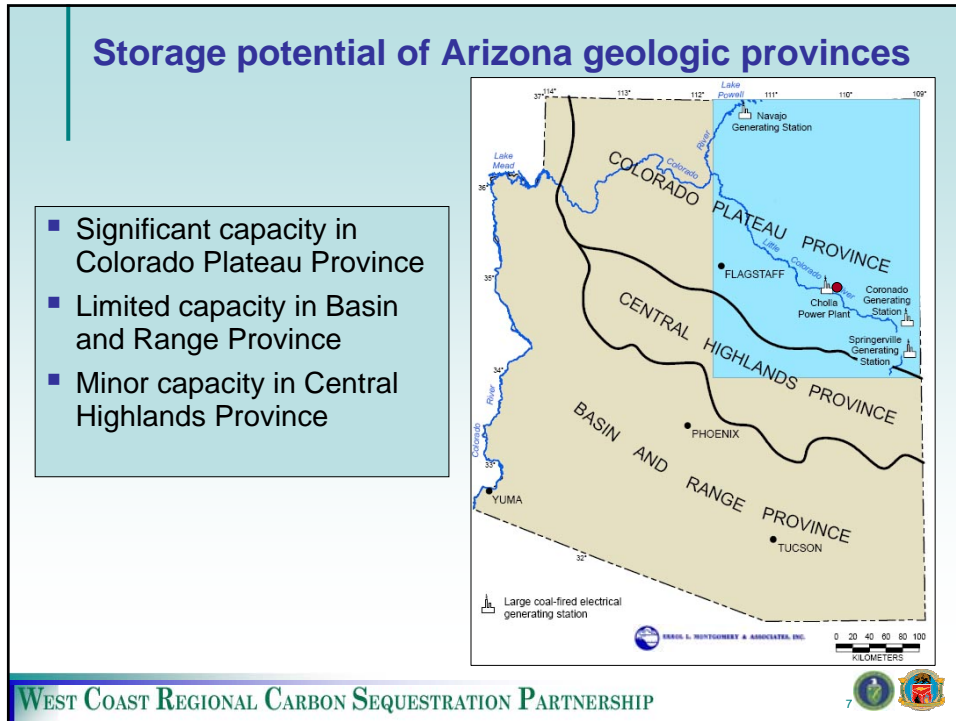


Sandia Technologies, LLC

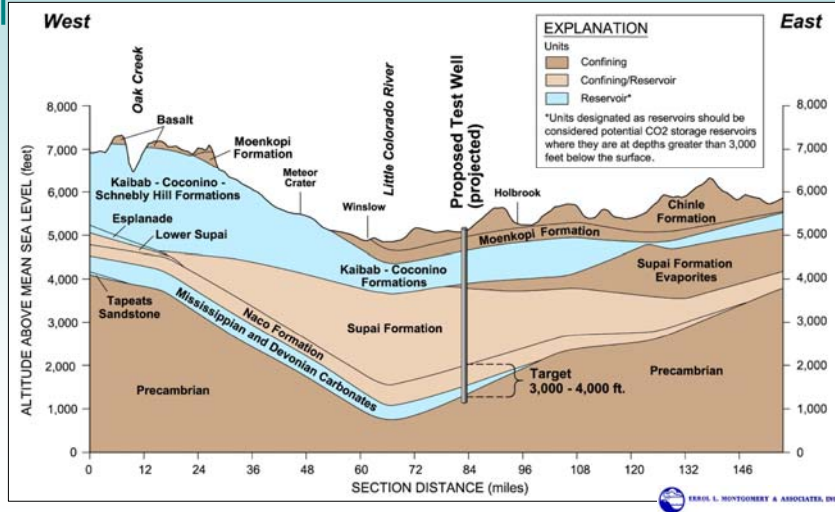


Source: R. Trautz, EPRI

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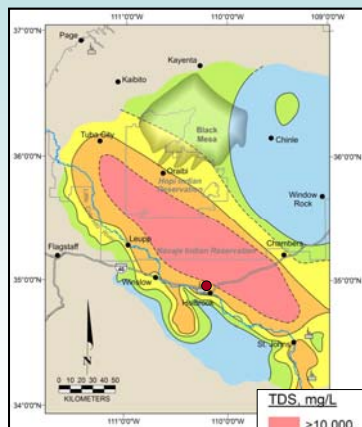
Geologic section in southern Colorado Plateau



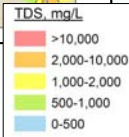
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Exploratory well to confirm suitability of site



TDS in Coconino Sandstone (USDW)



Geology at Project Site
Land Surface 5,100 Feet ASL

Moenkopi Formation	Silty Sandstone/ Gypsum	340	0
Coconino Sandstone	Sandstone	740	
Schnebly Hill Formation	Fine Sandstone	1,040	1,000
	Siltstone Mudstone Halite	1,865 1,885	2,000
Supai Formation	Limestone Marker Bed Siltstone Mudstone	2,525	3,000
	with minor Sandstone/Dolomite	3,075	
Naco Formation	Mudstone Limestone Sandstone Dolomite	3,575	
Martin Formation	Mudstone Siltstone	3,775	4,000
Pre-Cambrian Basement			

Source: Errol L. Montgomery & Associates

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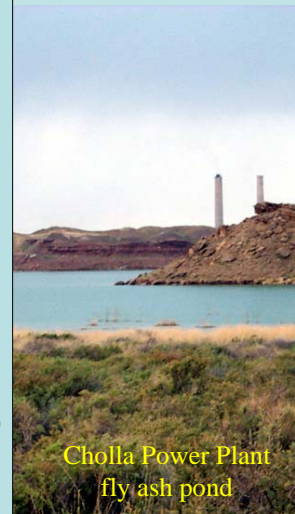


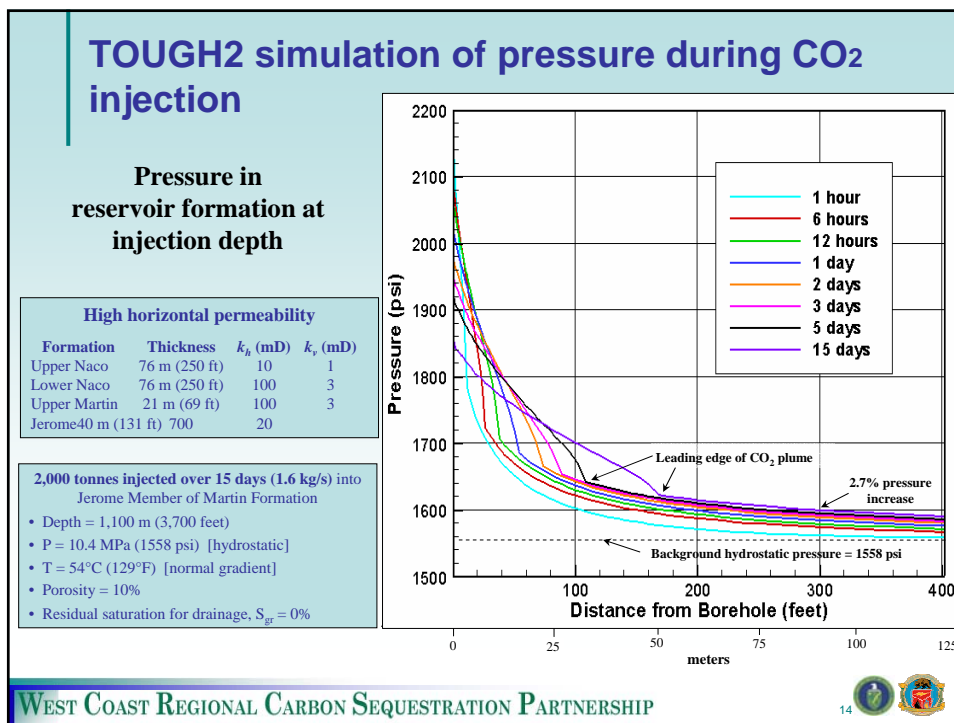
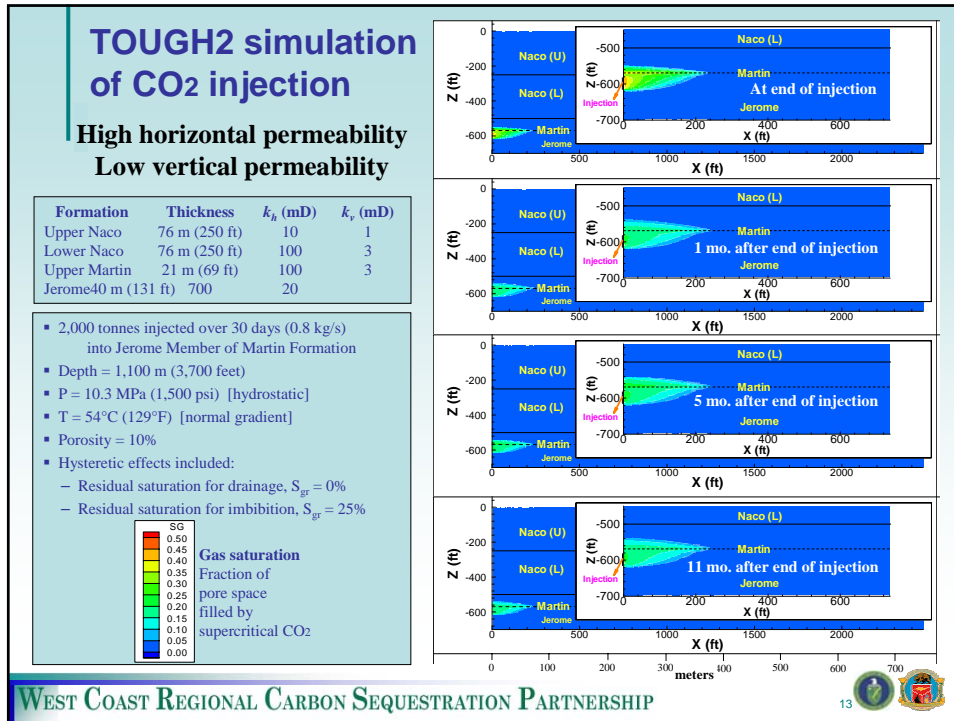
Scientific Objectives

- Evaluate CO₂ sequestration opportunities in the southern Colorado Plateau
- Demonstrate safe storage of CO₂ in porous carbonate formations containing nonpotable saline water beneath thick, low permeability cap rock
- Determine injectivity and storage capacity of the reservoir
- Develop, calibrate, and validate multiphase flow models for CO₂ injection into saline formations typical of northeastern Arizona
- Show that surface and borehole geophysical techniques can monitor the location of the injected CO₂ in the subsurface
- Assess and maintain caprock integrity

Test Plan

- Numerical simulation of CO₂ injection
- Drill and log a single well ~4,000 ft (1,200 m) deep near the APS Cholla Power Plant fly ash pond
- Ensure TDS of reservoir formation >10,000 mg/L
- Step-rate injection test to determine maximum injection pressure
- CO₂ huff-puff test for residual saturation estimate
- Inject 2,000 tonnes of commercial-grade CO₂
- Sample fluids with U-tube system; chemical analysis
- Pre- and post-CO₂ injection monitoring
 - Reservoir Saturation Tool (RST) logs
 - Vertical seismic profile (VSP) surveys
 - Distributed Thermal Perturbation Sensor (DTPS) logs
- Vent CO₂ from well; analyze fluids with phase-partitioning tracers





U-Tube System – continuous water, CO₂, and tracer samples at reservoir pressure

On-site chemical analysis

Pressurized sample storage

U-tube and check valve strapped to production tubing

Well

Packer

Source: Barry Freifeld, LBNL

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Assess and maintain seal integrity

- Perform step-rate injection test to determine safe injection pressure
- Monitor and control injection pressure at surface and reservoir
- Run Reservoir Saturation Tool* (RST) logs in injection well before and after CO₂ injection
- Monitor during and after CO₂ injection with Distributed Thermal Perturbation Sensor

* Schlumberger tool that measures thermal neutron absorption to infer water saturation, and C/O ratio with an induced gamma ray spectrometer.

Well Casing

Injection Tubing

Sampling Tube

Packer

Pressure Sensor

CO₂

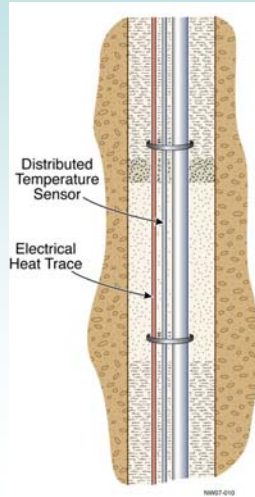
CO₂

Pressure Monitoring

RST Log

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Distributed Thermal Perturbation Sensor (DTPS) for tracking CO₂ migration in the subsurface



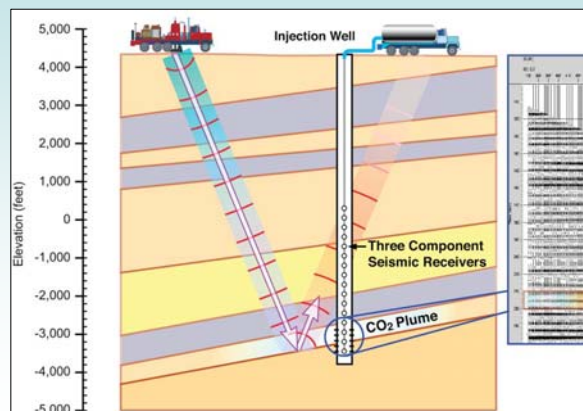
Thermal conductivity measurements during and after CO₂ injection monitor the distribution of CO₂ near the well

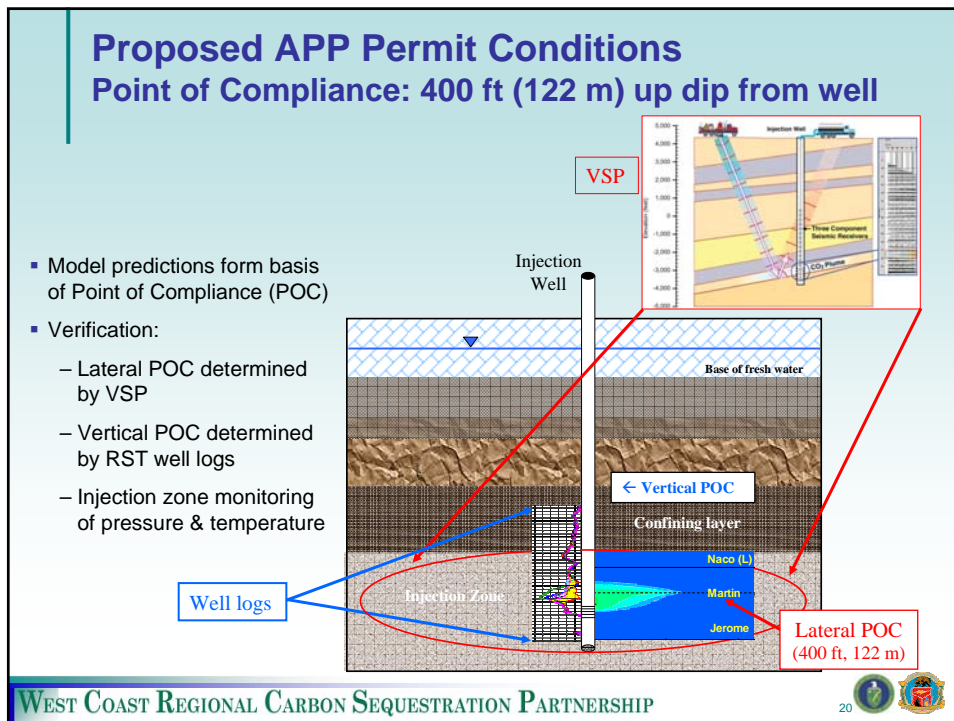
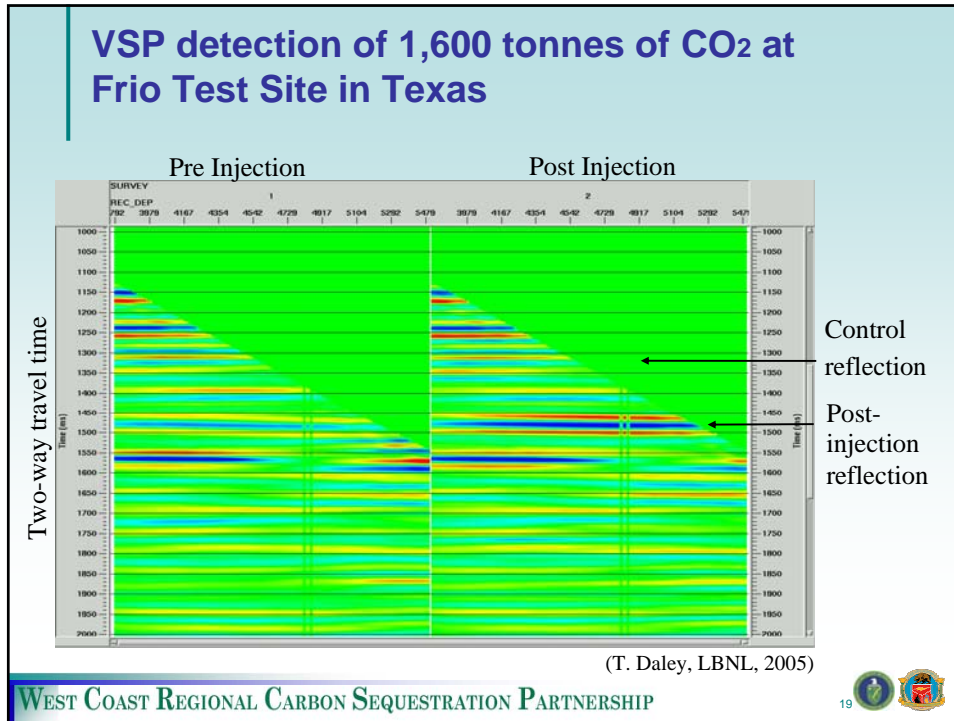
- The DTPS consists of a borehole-length electrical resistance heater and fiber optic distributed temperature sensor
- Constant heating is applied along the borehole, then is turned off. The temperature sensor measures the decay
- The low thermal conductivity of CO₂ versus water allows for estimates of CO₂ saturation
- The DTPS has been successfully tested at the CO₂SINK project in Germany

Source: Barry Freifeld, LBNL

Vertical seismic profile (VSP) survey

- To be performed in time-lapse mode, pre- and post-CO₂ injection
- Supercritical CO₂ displaces some formation water and reduces seismic velocity





Other Essential Activities

- Engage state and federal agencies in the CO₂ injection process
- Obtain permits
 - ✓ National Environmental Policy Act (NEPA)
 - ✓ U.S. EPA Underground Injection Control (UIC)
 - ✓ Arizona Department of Environmental Quality Aquifer Protection Program (APP) permit (*no limit on TDS for an "aquifer"*)
 - ✓ Arizona Oil & Gas Conservation Commission drilling permit
- Conduct outreach to educate and receive input from the public regarding climate change and geologic sequestration
- Share our results with the community and public officials; compare our results with those from 20 similar tests across the United States and Canada



Arizona Utilities CO₂ Pilot Summary WESTCARB has...

- Completed a site hydrogeologic study
- Selected a drilling site for the pilot
- Added new industry partners
- Selected a site test manager
- Written a project test plan
- Modeled CO₂ plume size and formation pressure
- Received NEPA approval from DOE
- Submitted APP and UIC permit applications
- Engaged in public outreach to the community through public meetings
- Developed detailed budgets and schedules
- ...and will begin
 - Drilling and testing in January 2009

PUBLIC MEETING
Storing Carbon Dioxide to Fight Global Warming:
Arizona Utilities CO₂ Storage Pilot Project

Holbrook, Arizona, August 1, 2007, 6:30-8:00 p.m.

Purpose
This informational meeting is being held to discuss plans for a research project to test "carbon sequestration," a promising new technology that can help carbon dioxide (CO₂) escape from the atmosphere and curb global warming. We know as CO₂ storage, carbon sequestration involves capturing CO₂ from a wide range of industrial processes, gasification facilities, and various large-scale storage by chemical, biological, mineral, or geological means. In some cases, CO₂ storage is used to enhance oil recovery (EOR), storage. The depth and high volume of the water in these formations will not be the primary use of CO₂ in these formations but the possibility of using it for biomass conversion or agriculture. The project

CO₂ storage will be used to store a small amount of commercial-grade CO₂ from a pilot-scale facility equipped with sensitive monitoring systems. This will allow researchers to "test" the CO₂ as it is distributed into the porous rock. Successful subsurface storage will provide a model for the feasibility of ultimately storing CO₂ captured from nearby power plants, which could be required by future regulations.

Everyone is welcome to attend the meeting to learn and ask questions about our proposed project. [Please see our Q & A section on the back of this announcement.]

MEETING LOCATION
Northern Phoenix College
Pioneer Center Building
211 N. Saginaw Boulevard
Holbrook, AZ 86001
Meeting Contact: Susan Grady, 928-226-8500
E-mail: SGrady@nphoenixcollege.edu