WESTCARB Phase II Northern Arizona Saline Formation CO_2 Storage Pilot Test

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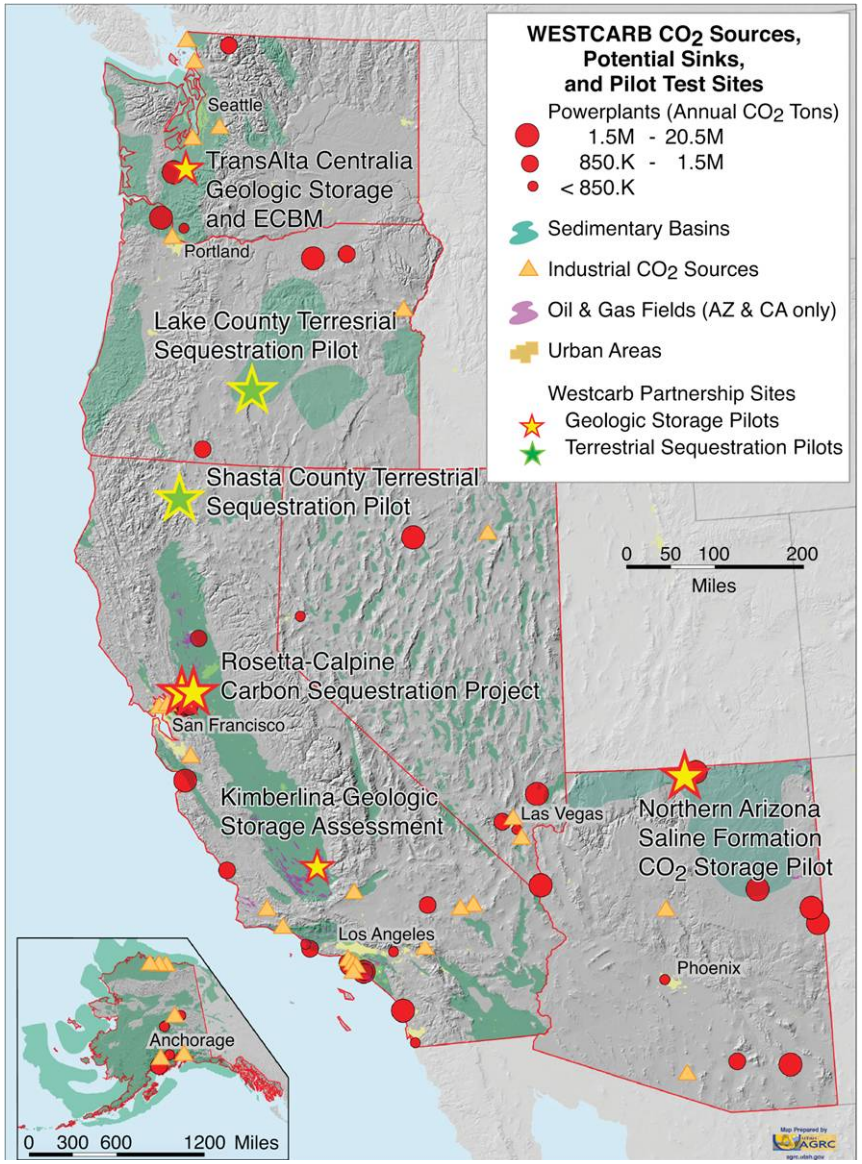
WESTCARB Geologic Storage Pilots

- Northern Arizona Saline Formation CO_2 Storage Pilot
- Partners
  - Salt River Project
  - EPRI
- 30 Mt CO2 sources from coal-fired power plants
  - Navajo Generating Station
  - Coronado Generating Station
  - Springerville Generating Station
- Focus on siting for future power plants



Pilot Test Objectives

- Demonstrate the safety and feasibility of CO_2 storage in saline formations in the vast Colorado Plateau region in Arizona;
- Demonstrate and test methods for monitoring CO_2 storage projects in consolidated sandstones, shale and carbonate fields; and
- Gain experience with regulatory permitting and public outreach associated with CO_2 storage in a saline formation in Arizona.

Phased Approach to the Pilot Test

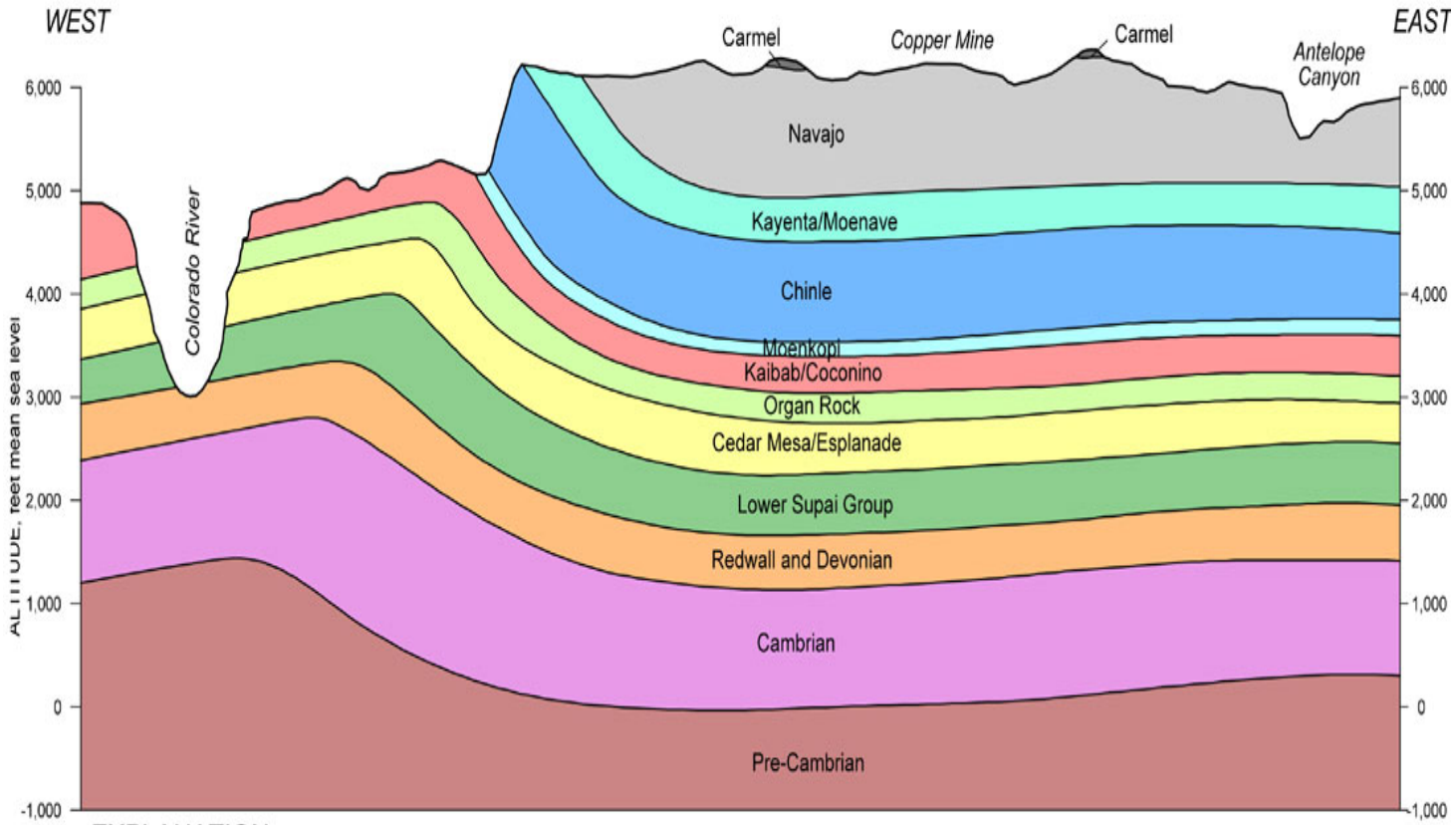
- Phase I. Pre-pilot planning, geologic characterization and outreach
- Phase II. Characterization, detailed pilot project planning and permitting
- Phase III. CO_2 injection, monitoring and storage assessment

Options

Site Assessment

Injection and Monitoring

Phase I. Assessing Options



Schematic showing the subsurface lithology in Northern Arizona. Potential storage formations include the Cedar Mesa Sandstone and the Redwall Limestone. In some areas, the Kaibab Limestone and Coconino Sandstone may also be suitable storage formations.

Potential Storage Formations and Seals

Table 1

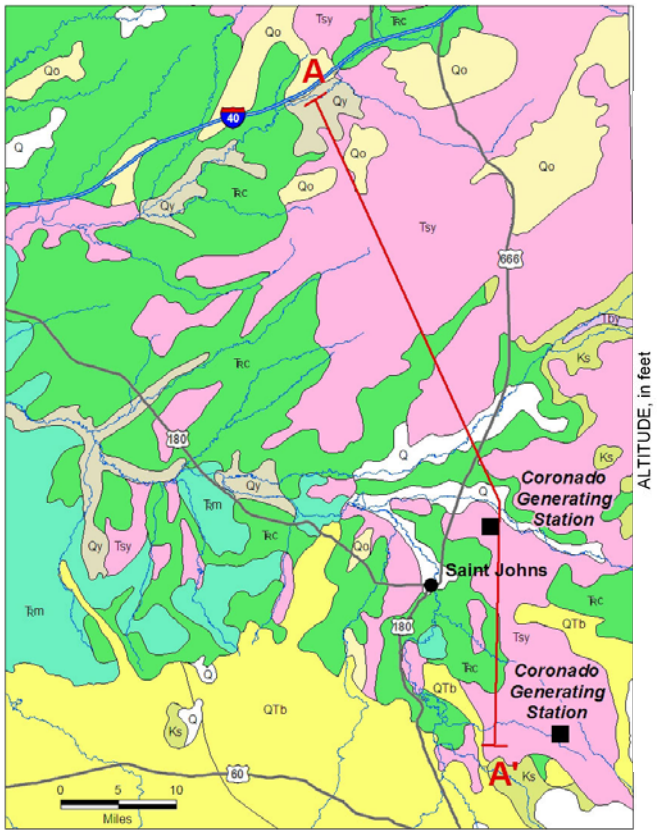
Formation	Top Elevation	Depth (ft)	Thickness(ft)
Chinle-Moenkopi	3825	525	1155
Kaibab Limestone	2670	1680	15*
Coconino Sandstone	2655	1695	555
Organ Rock Shale	2100	2250	455
Cedar Mesa Sandstone	1645	2705	1315
Redwall Limestone	-235	4585	545
Muav Limestone-Bright Angel Shale	-1525	5875	615
Tapeats Sandstone	-2140	6490	330**

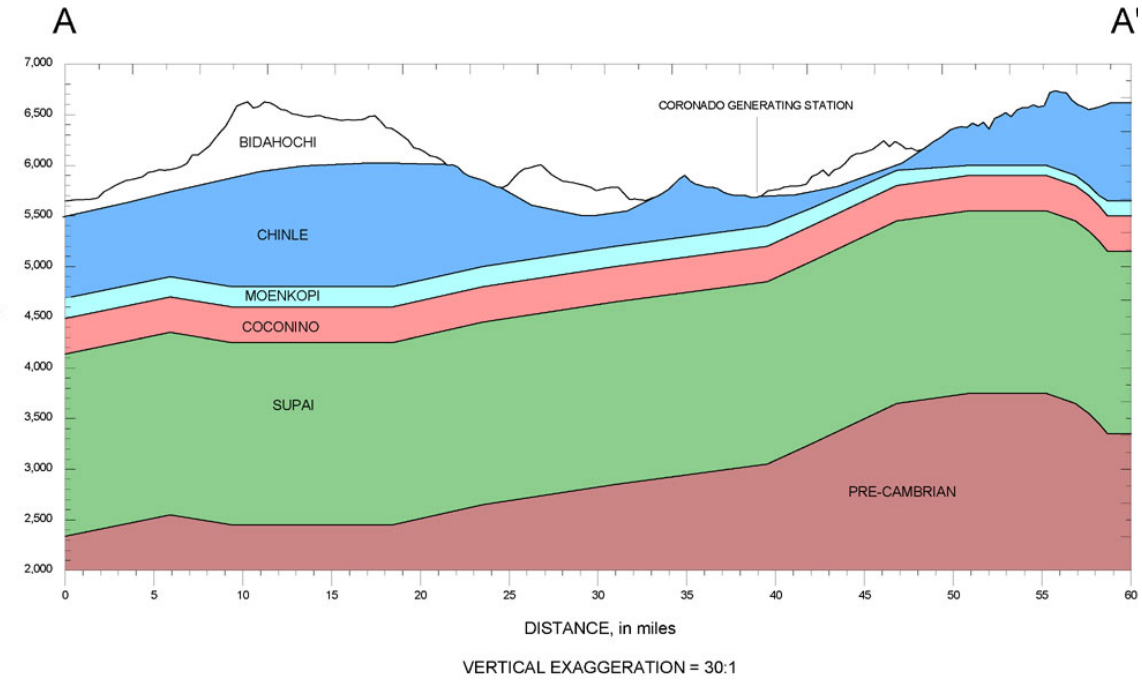
*=Assumes Kaibab pinches out at Sinclair Oil well

**= Estimate, R. Allis Utah Geo. Survey

Potential storage reservoirs are indicated by the white color of the boxes, seals are indicated by gray shading. The water table is Northern Arizona can be up to 1,000 feet deep, making deeper storage targets more attractive options.

Assessing Options: Geologic Structure Near the Coronado Generating Station





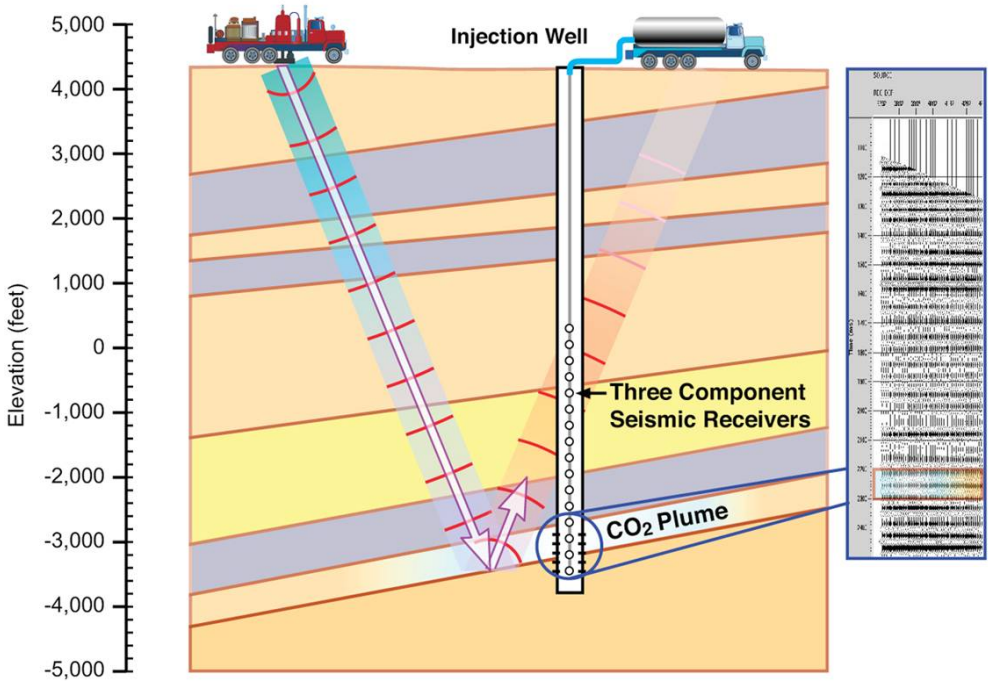
From Errol Montgomery and Associates 2006

Phase I. Public Outreach

- Meetings have been held with local regulators regarding the project.
  - Constructive interaction
  - Agreed to participate on an advisory committee for the project
  - Suggested members for advisory board
- An advisory committee for the project has been established and the first meeting has been held

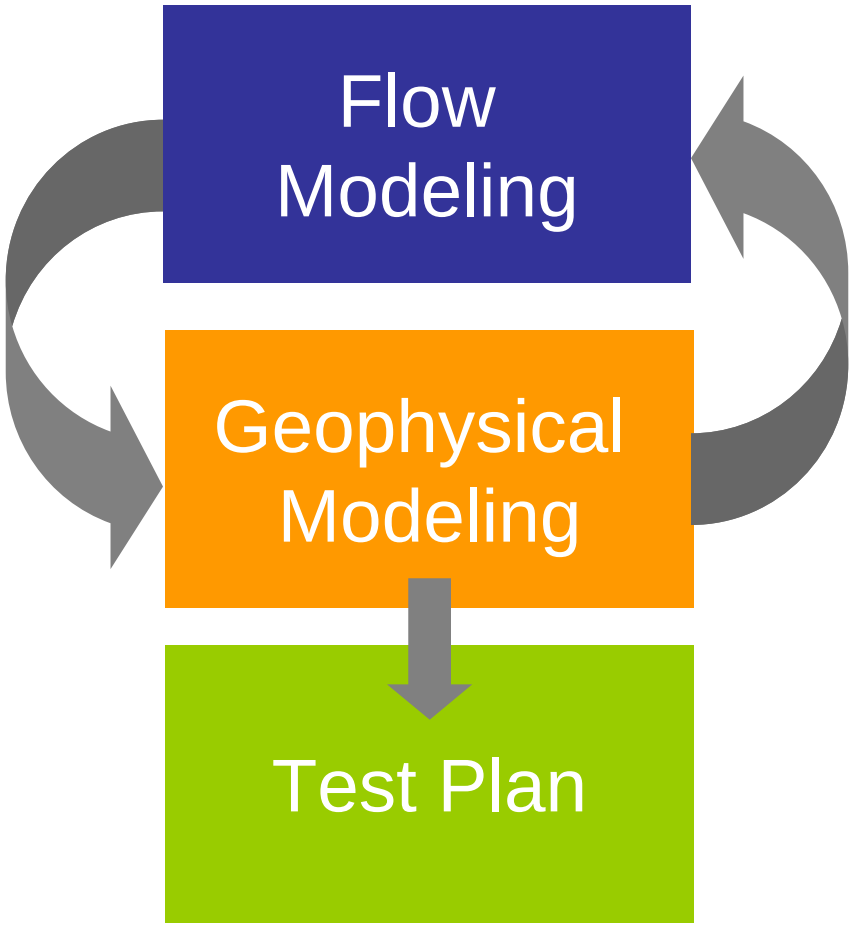
Phase II. Detailed Site Characterization

- Drill a single well
  - Geologic logs
  - Geophysical logs
  - Short term permeability tests of promising injection zones
- Assess most promising options for CO_2 storage test
- Assess regional storage potential



Phase III. CO_2 injection, monitoring and storage assessment

- CO_2 Injection
  - ~2,000 tonnes
  - Manufactured or natural source
- Monitoring
- Seal integrity assessment
- Injectivity assessment
- Capacity assessment



Phase III. Monitoring

Measurement technique	Measurement parameters	Application
Fluid composition	CO2 & natural gas composition Brine salinity, alkalinity, pH and composition	Predict solubility and mineral trapping Quantifying CO_2-water-rock interactions
Subsurface pressure	Reservoir pressure Overlying reservoir 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	Gamma, SP, resistivity Brine salinity Sonic velocity CO_2 saturation (RST)	Lithology Tracking CO_2 movement in and above storage formation Tracking migration of brine into shallow aquifers Calibrating seismic velocities for VSP surveys
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
Cap rock integrity (if feasible)	Leakoff test	Natural stress state
CO_2 land surface flux monitoring using flux chambers and eddy covariance	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

Benefits to the Region

- Large and growing CO_2 sources
- Favorable geology for geological storage
- Assessment of CO_2 storage potential
  - Seal integrity
  - Injectivity
  - Capacity