Potential for CO_2 Capture and Storage in Geological Formations in the West

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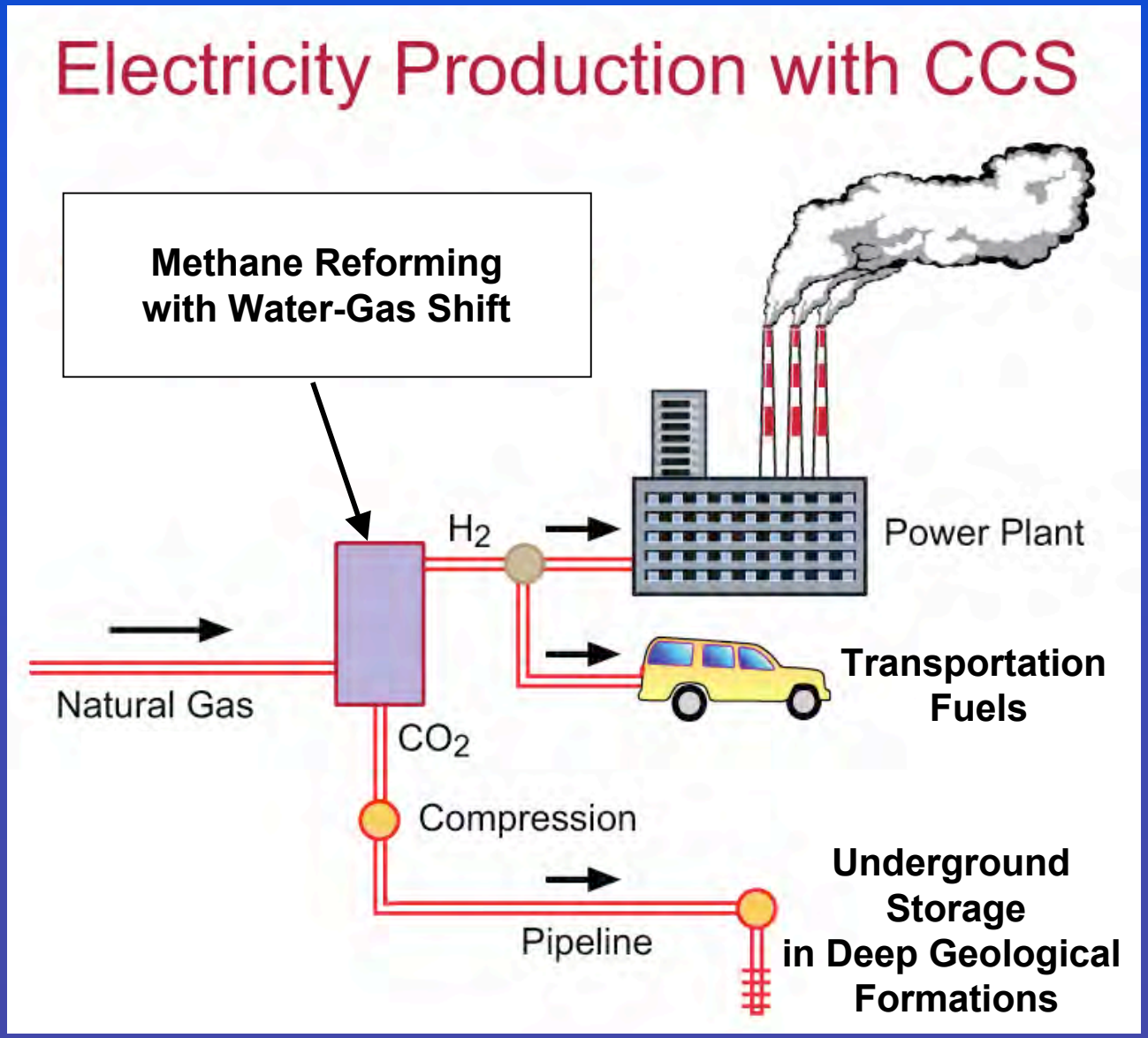
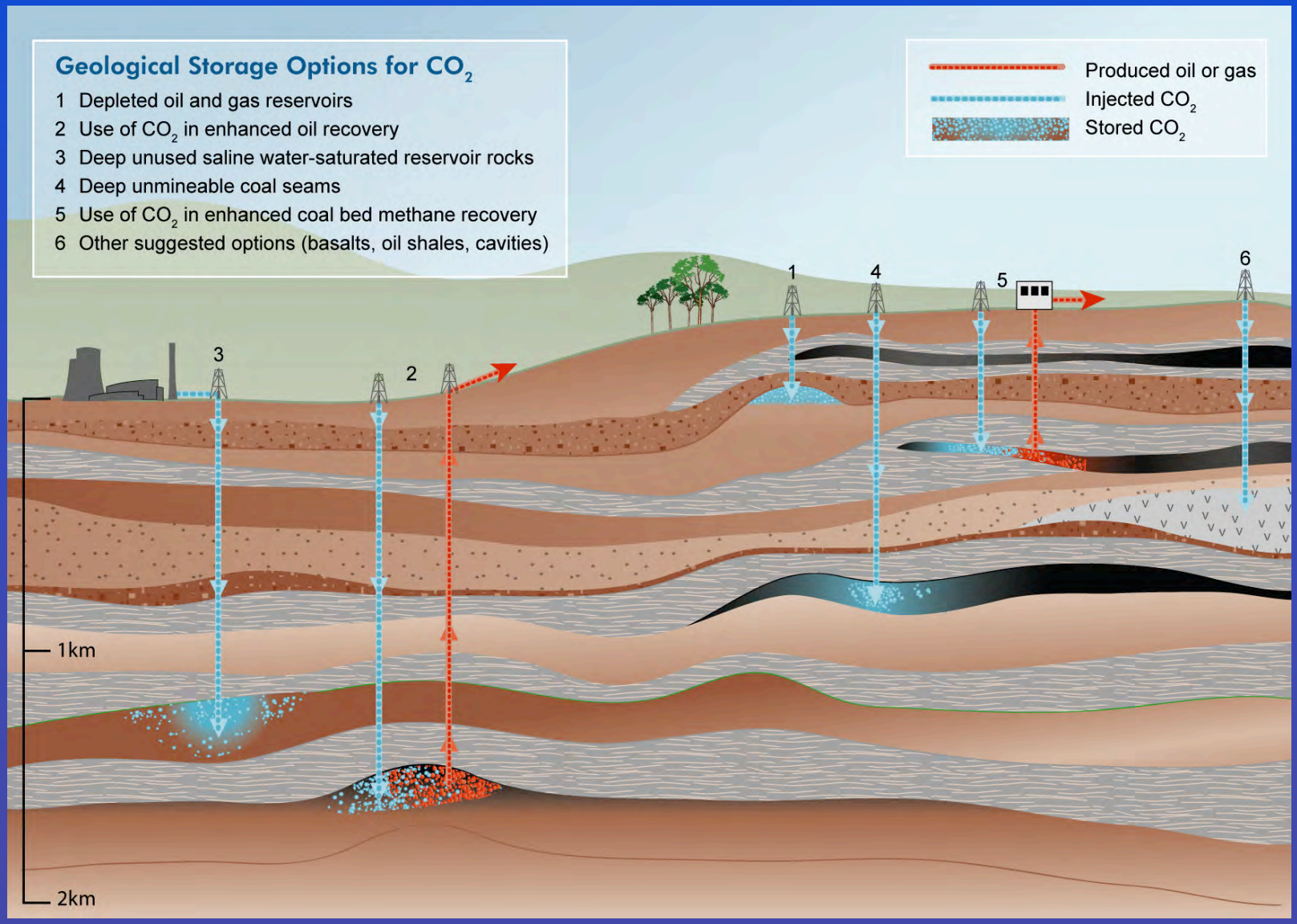
CO_2 Capture and Storage Technology

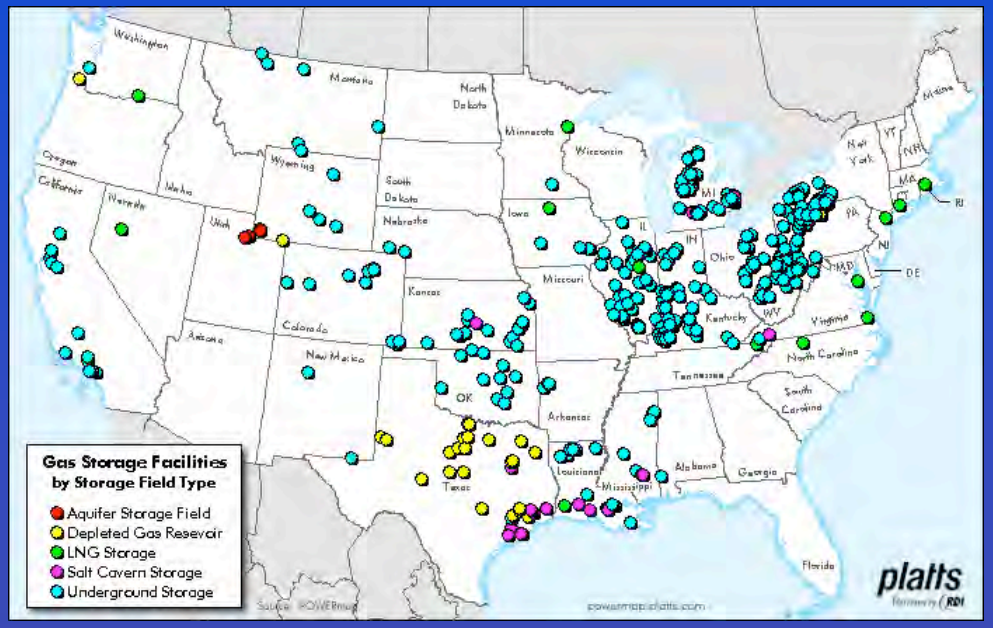


Options for Geological Storage



Many Lines of Evidence Indicate Storage Can Be Secure and Effective

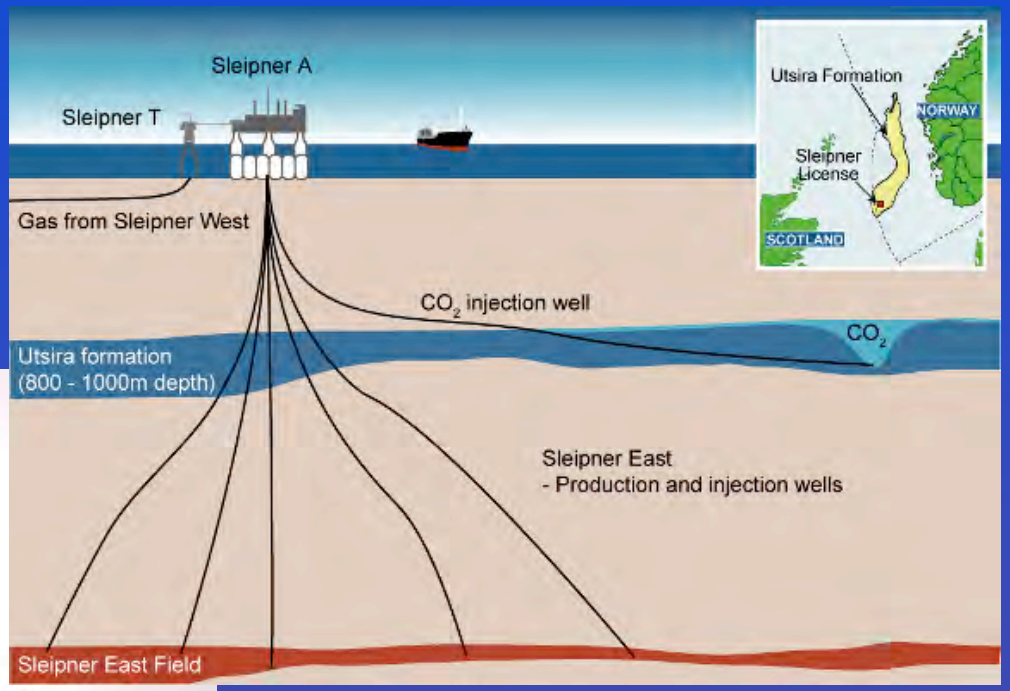
- Natural analogues
  - Oil and gas
  - CO_2 formations
- Industrial analogues
  - Natural gas storage
  - CO_2 EOR
  - Liquid waste disposal
- Fundamental physical and chemical processes
- Numerical simulation
- Monitoring existing projects
  - Sleipner
  - Weyburn



Location of natural gas storage projects in the U.S.

Sleipner Project, North Sea

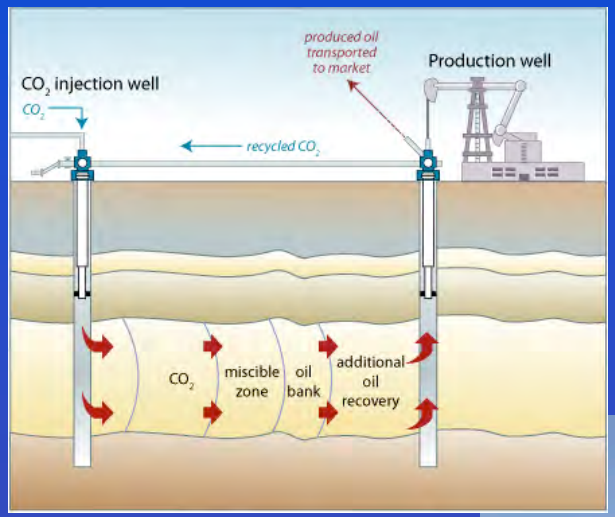
- 1996 to present
- 1 Mt CO_2 injection/yr
- Seismic monitoring



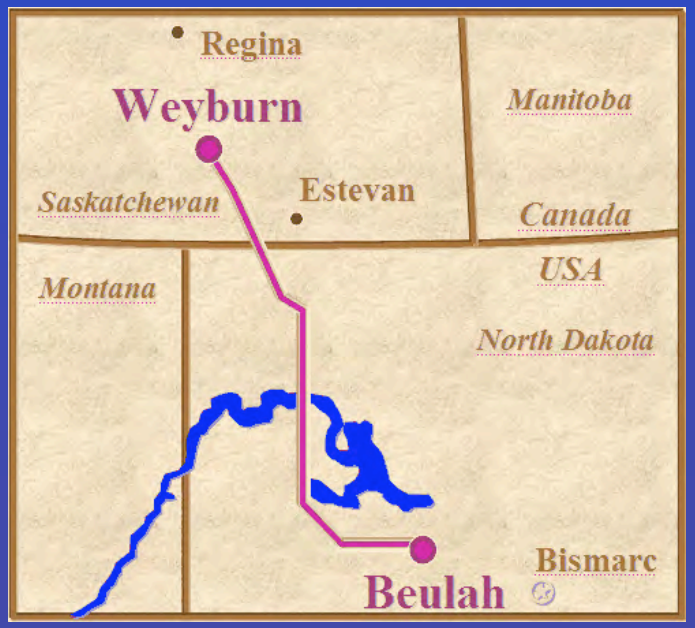
Picture compliments of *Statoil*

Weyburn CO_2-EOR and Storage Project

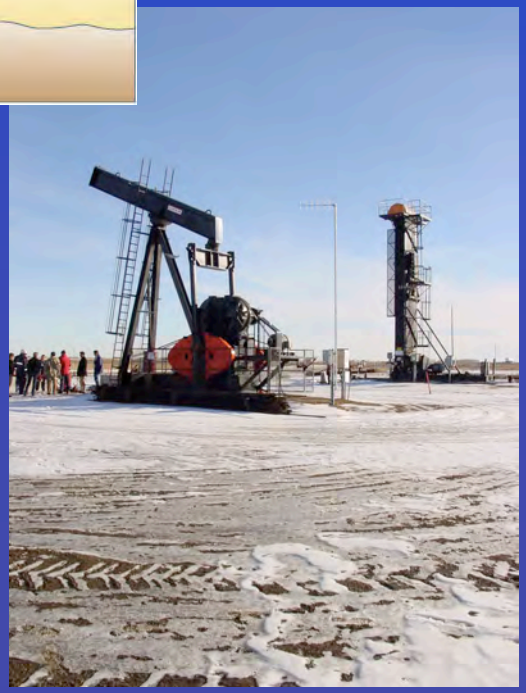
- 2000 to present
- 2.7 Mt/year CO_2 injection
- CO_2 from the Dakota Gasification Plant in the U.S.



after IEA Greenhouse Gas R&D Programme



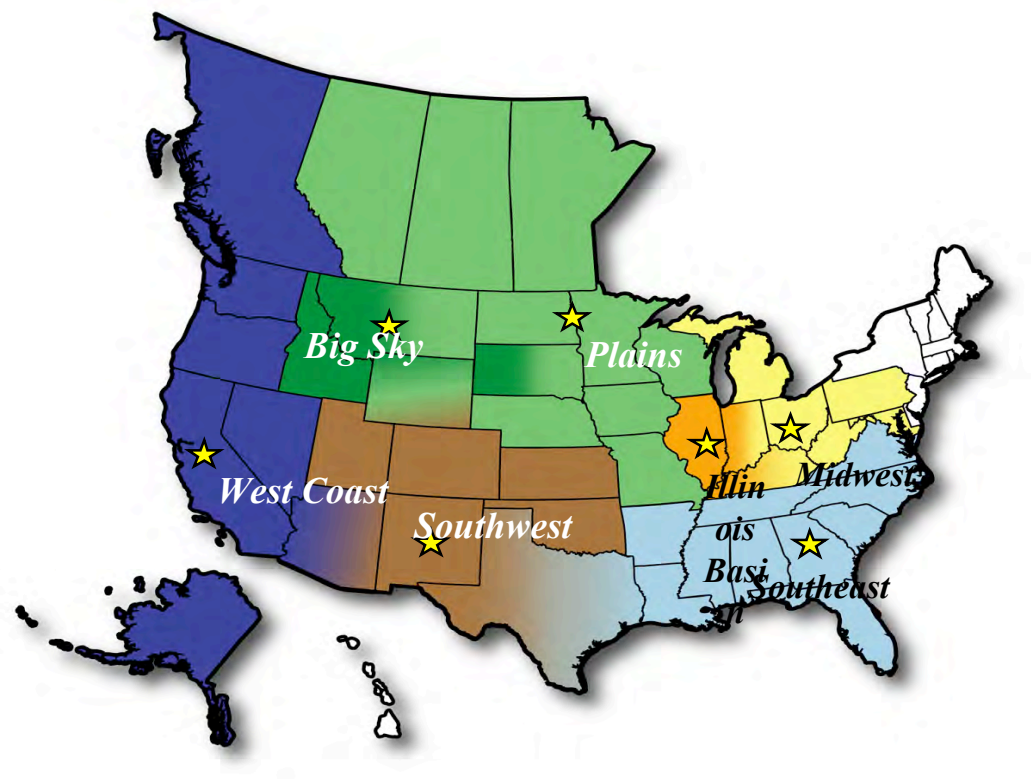
- Over 70 projects in west Texas
- Significant potential in California



Courtesy of PTRC and Encana

WESTCARB: Addressing Four Major Questions

1. Where are the sources of CO_2 and how much is there?
2. Where can it be stored?
3. How much will it cost?
4. Will it be safe?



7 Regional Carbon Sequestration Partnerships

CO_2 Storage in the West

WESTCARB CO_2 Sources, Potential Sinks, and Pilot Test Sites

Powerplants (Annual CO_2 Tons)

- 1.5M - 20.5M
- 850.K - 1.5M
- < 850.K

Sedimentary Basins

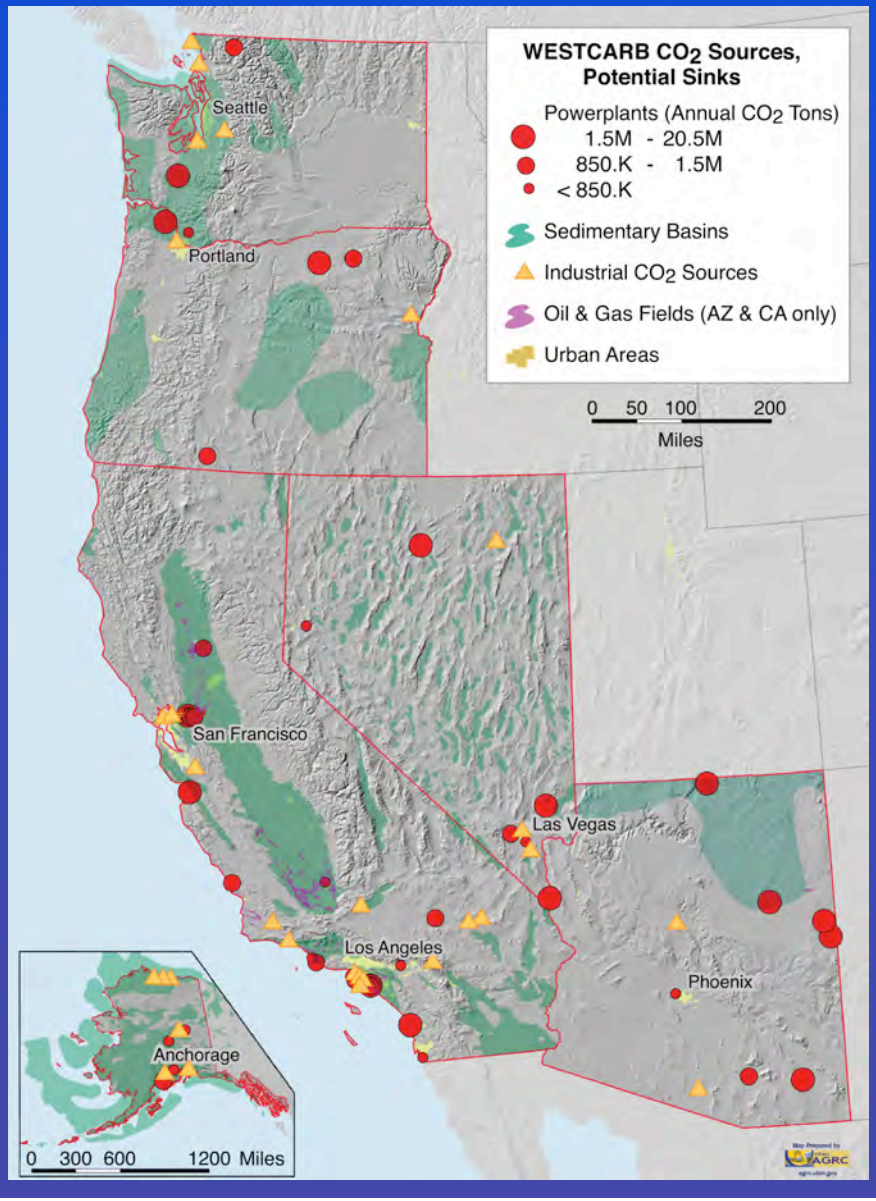
Industrial CO_2 Sources

Oil & Gas Fields (AZ & CA only)

Urban Areas

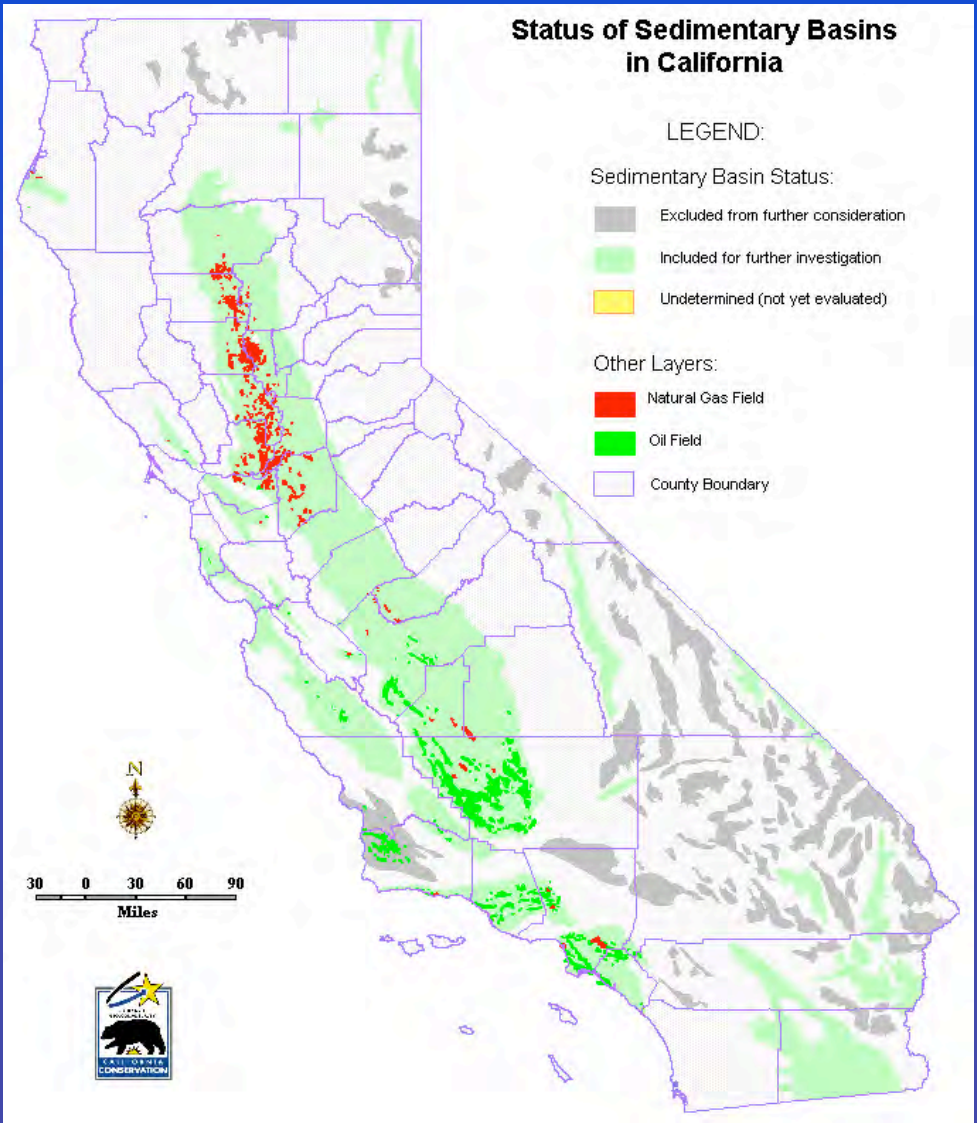
Westcarb Partnership Sites

- Geologic Storage Pilots
- Terrestrial Sequestration Pilots



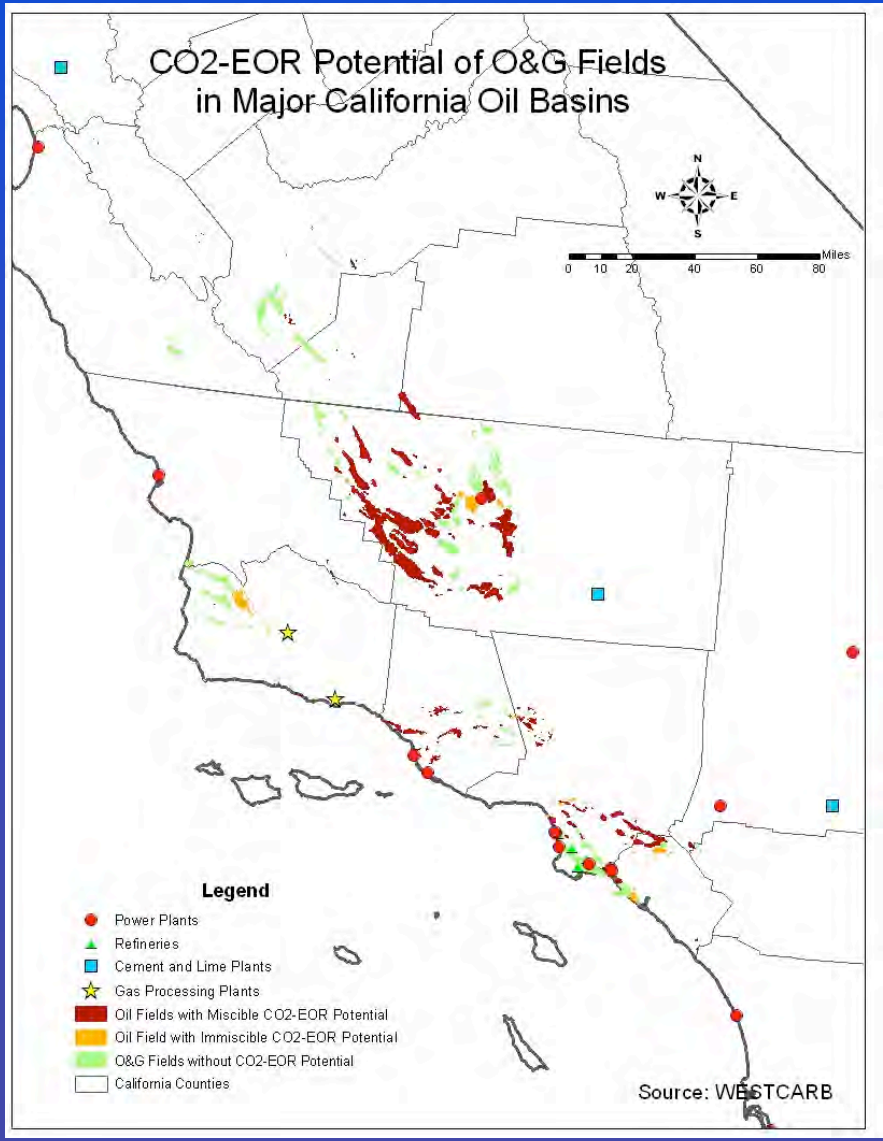
California Has Many Options for Geological Storage

- Oil reservoirs
- Gas reservoirs
- Saline formations
  - 104 basins screened
  - 77 eliminated

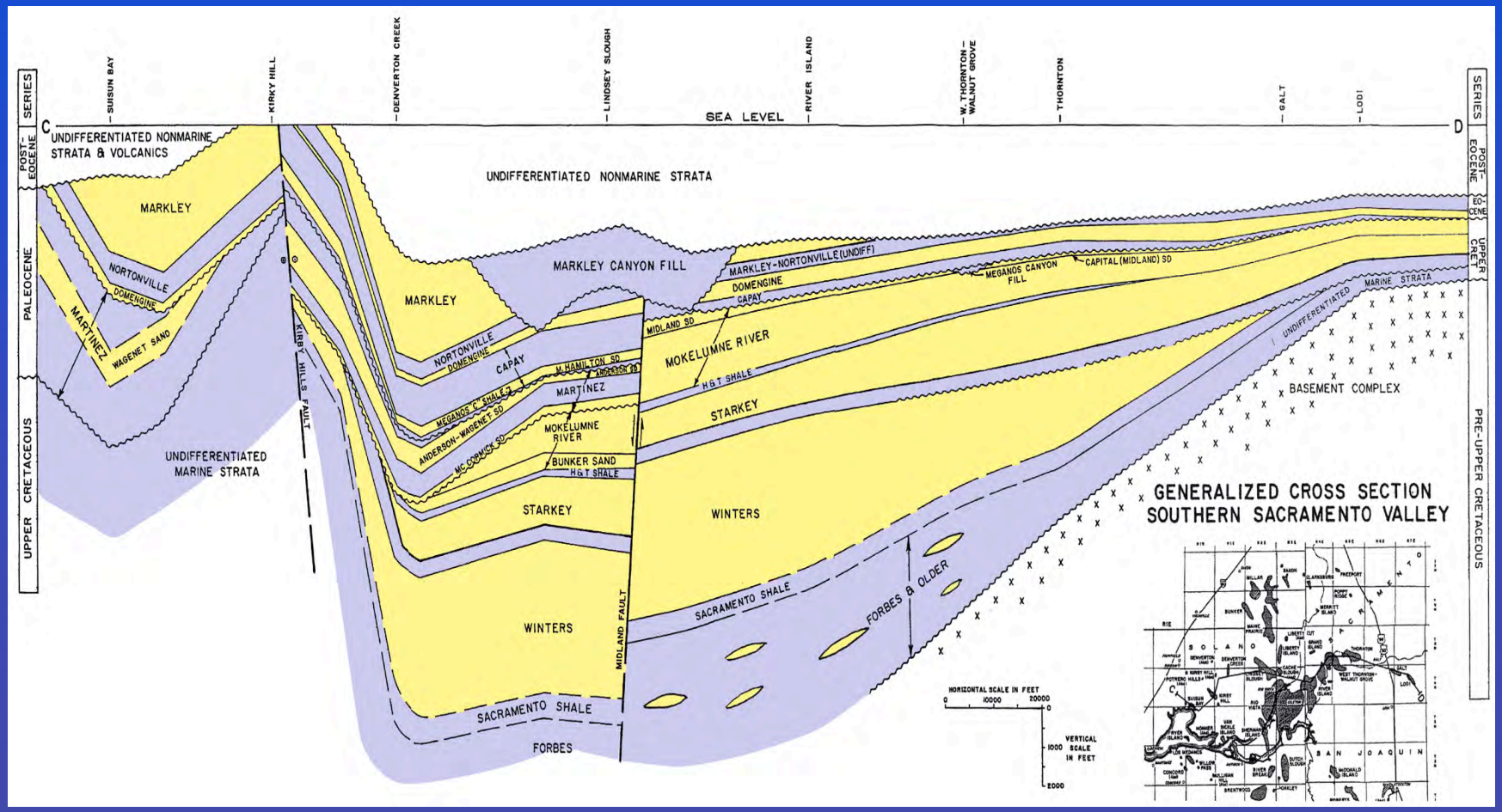


Significant Opportunities for EOR and EGR

- 121 fields met depth and miscible EOR criteria
  - 3.4 Gt CO_2 storage capacity, using production as a basis
  - Other studies suggest 5.4 billion barrels oil technically recoverable
- 128 gas fields met depth criteria
  - 1.8 Gt CO_2 storage capacity

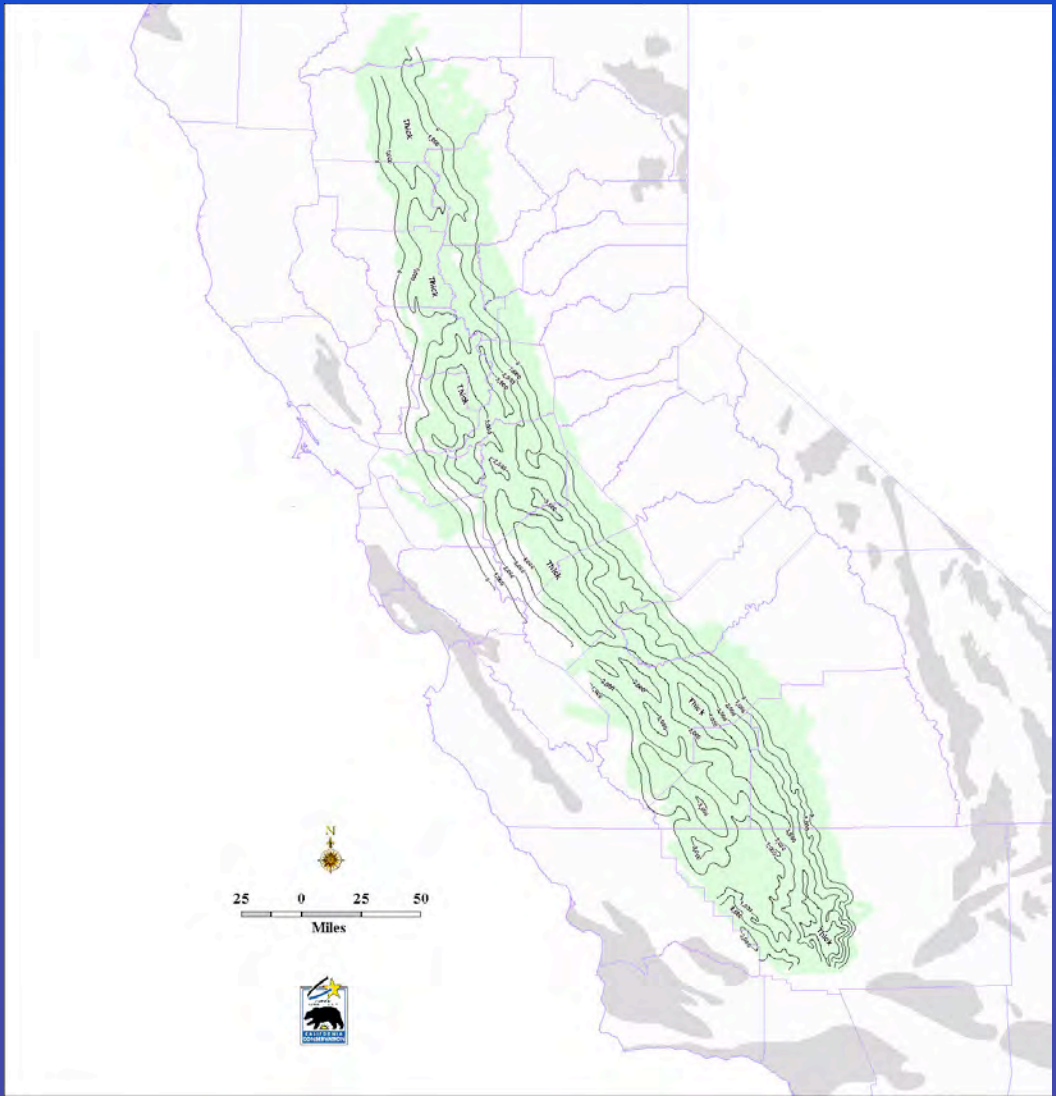


Generalized Cross-section of Southern Sacramento Basin



Sand Isopach Map Provides Basis for Estimate of Capacity

- Sand thickness calculated for interval from 2,625ft (800m) to 10,000ft
- Sand thickness in excess of 4,000ft found in several areas



Volumetric Estimates Made for 10 Largest Basins

Table 1. Data used for calculation of pore volume of California basins

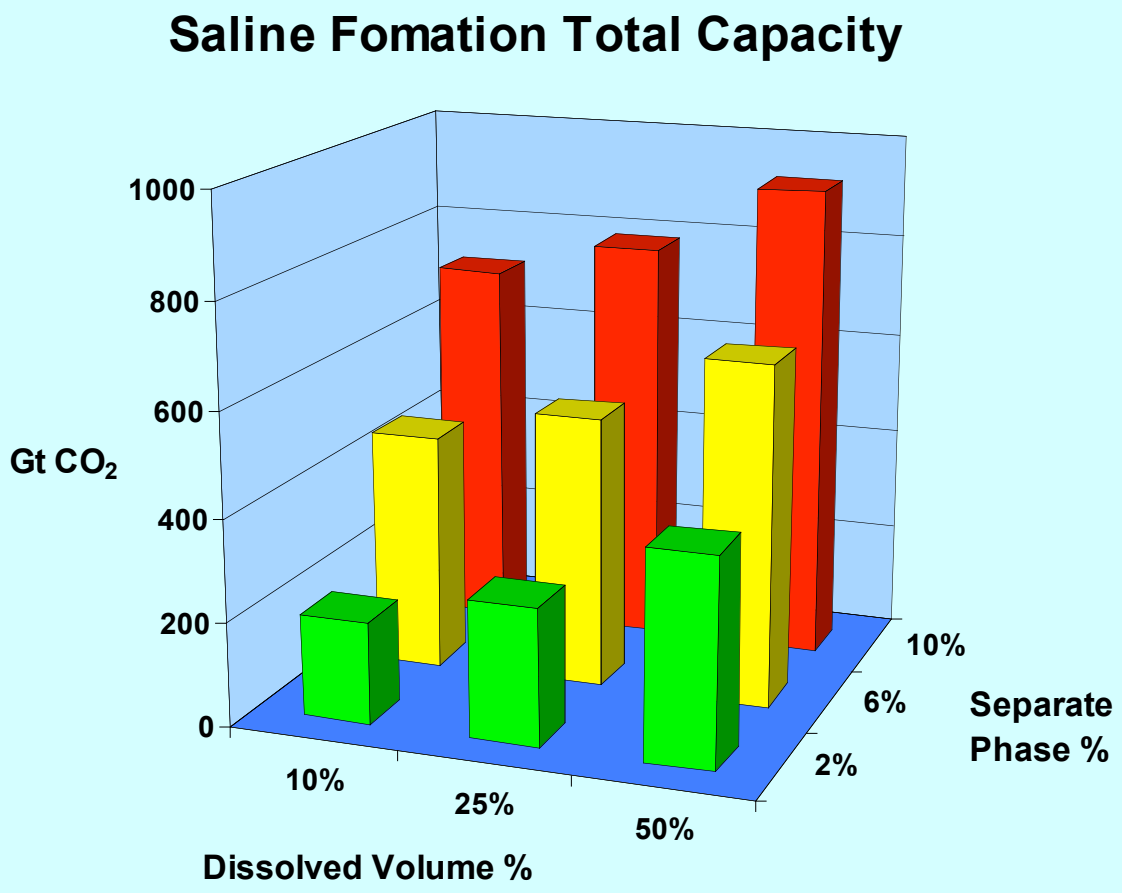
Volumetric Data for California Basins				
	Area (sq. miles)+	Estimated Average Thickness (ft.)*	Estimated Average Porosity**	Pore Volume (cu. meters)
Sacramento-San Joaquin basins	18,550	2,000	0.25	7,321,941,287,906
Salton Trough	2,559	2,000	0.24	969,669,749,085
Ventura Basin	1,450	3,000	0.24	824,162,447,932
Los Angeles Basin	1,341	3,000	0.25	793,966,841,004
Cuyama Basin	582	3,000	0.27	372,151,974,334
Salinas Basin	1,343	1,250	0.28	371,070,458,478
La Honda Basin	268	1,500	0.25	79,337,477,028
Eel River Basin	175	1,500	0.26	53,878,435,892
Orinda Basin	296	600	0.23	32,246,539,917
Livermore Basin	144	800	0.23	20,916,674,541

+Area of basin at depths greater than 2,625 ft. (800 m)

*Average sands (isopachs) thickness for depth window 2,625 ft (800 m)- 10,000 ft

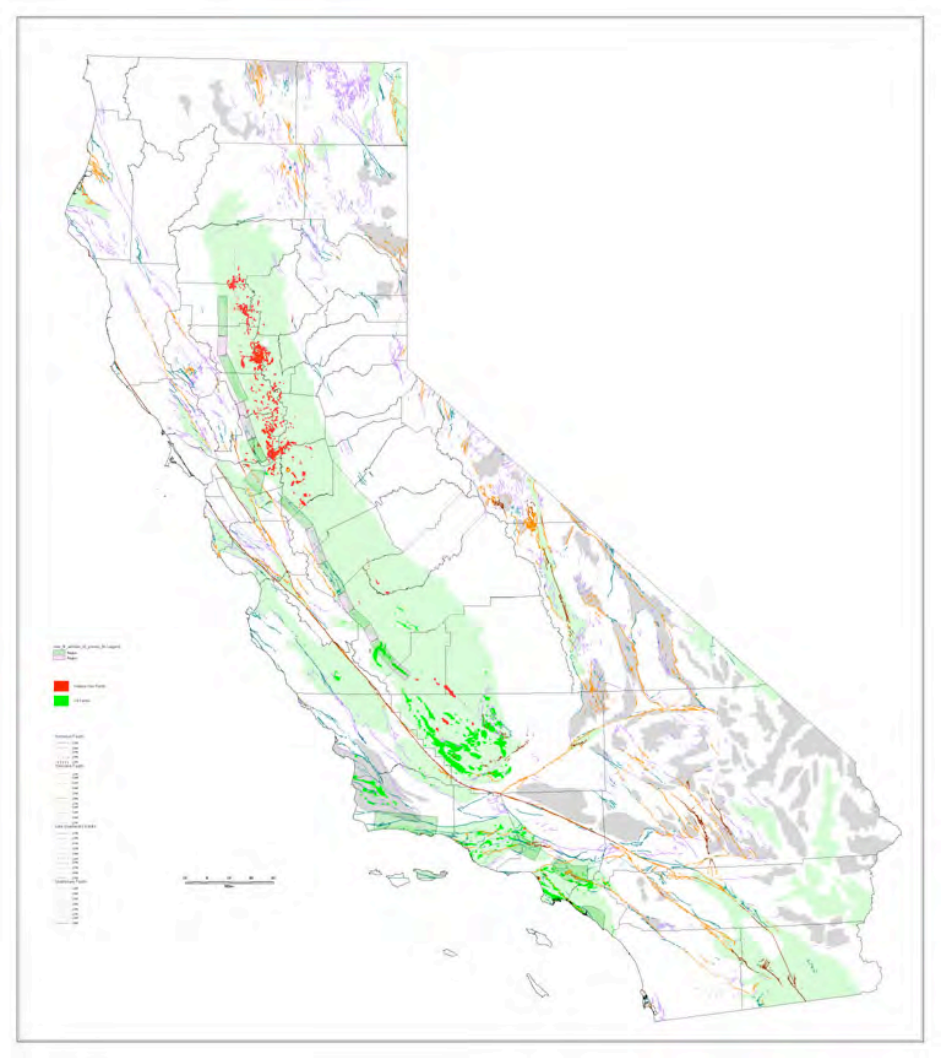
**Approx. average porosity for all zones in isopachs window

CO_2 Storage Capacity of 10 Largest Basins is Immense



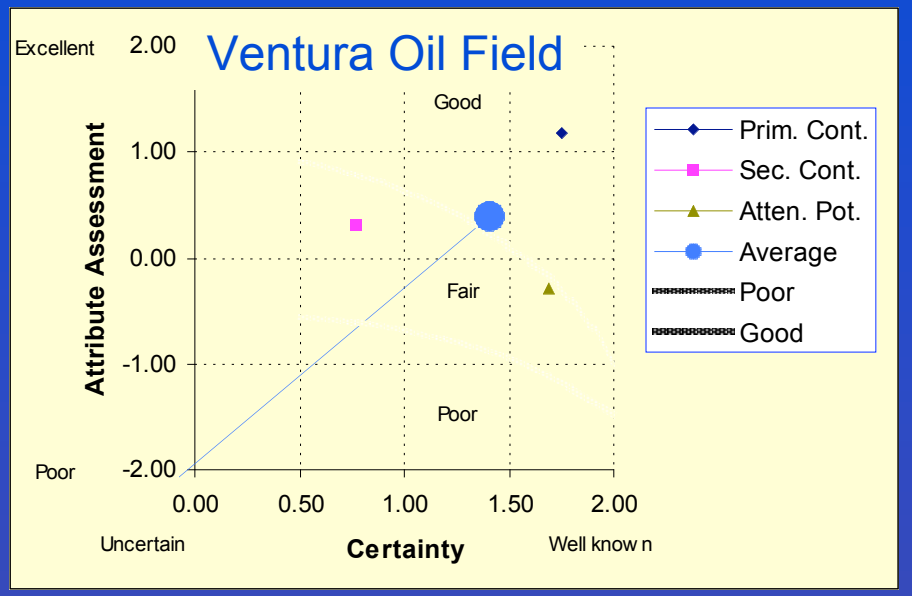
Low Occurrence of Quaternary Faulting in Many Basins

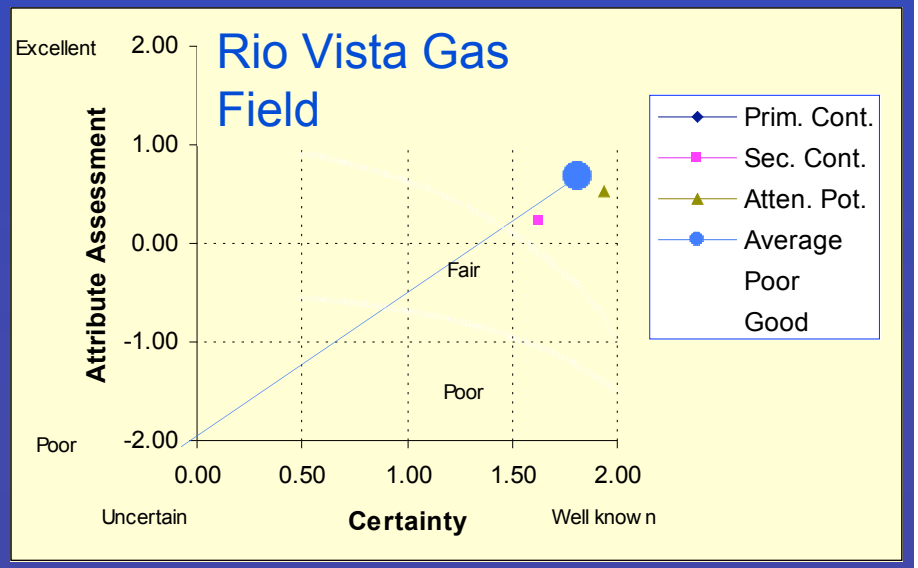
- Hydrocarbons have remained trapped in faulted basins
- In Central Valley faulting is absent except at southern end; deep thrust faulting along western margin



Site Selection Tool Screening Geologic Storage Sites

- Spreadsheet model for site selection has been developed
- User can
  - Evaluate and score various attributes
  - Specify the importance of various attributes through weighting factors
  - Specify uncertainty inherent at sites



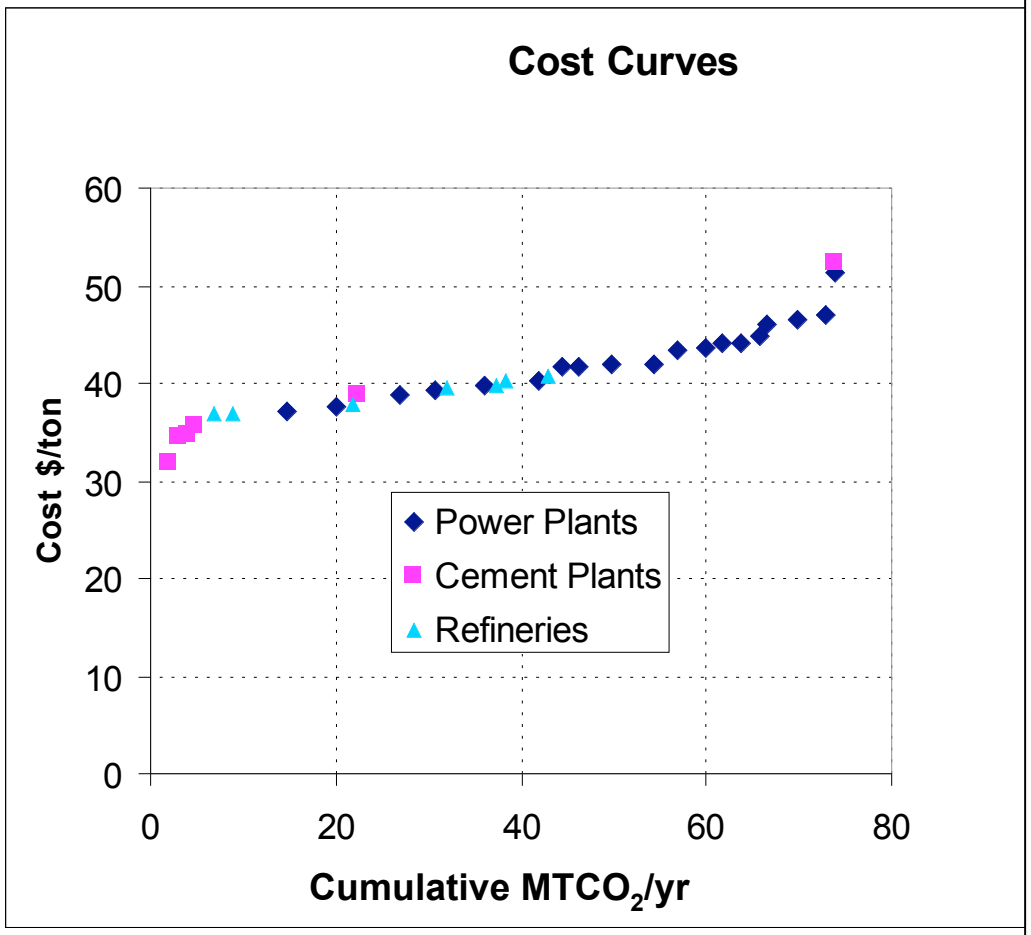


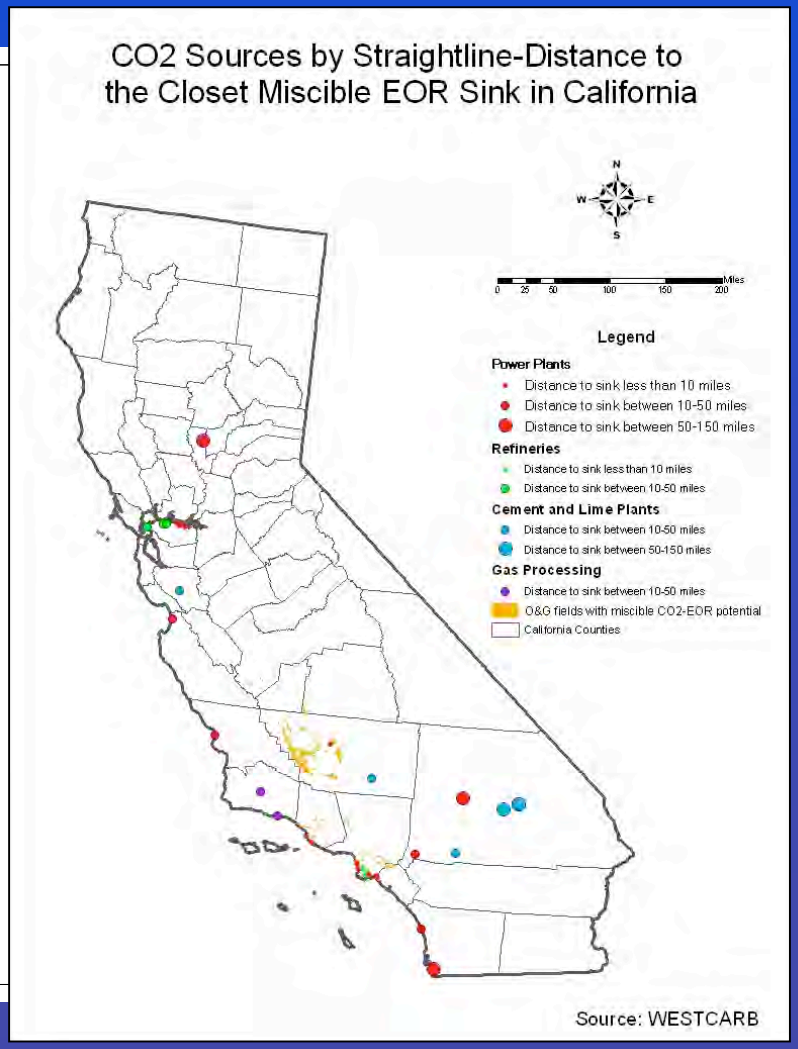
Generic Cost of CCS

Capture	$30-$70/t avoided
Geological Storage	$2-$8/t
Total	**$32-$78/t avoided**

Costs for electricity production increase from 1-5¢/kwhr ~50% increase in costs

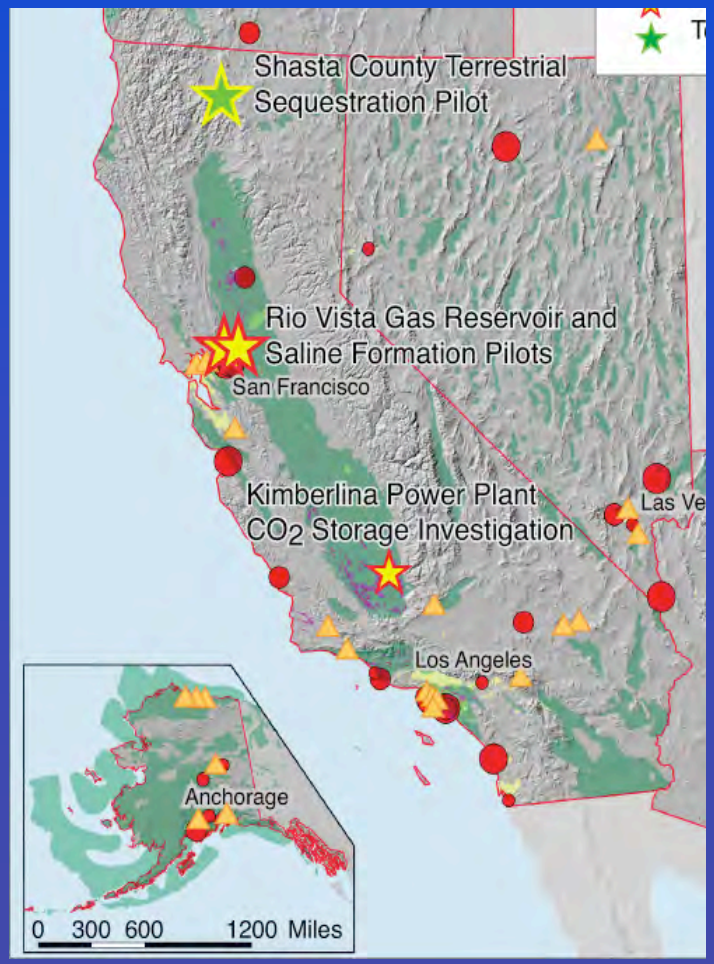
Capture Costs For Retrofitting Existing Plants

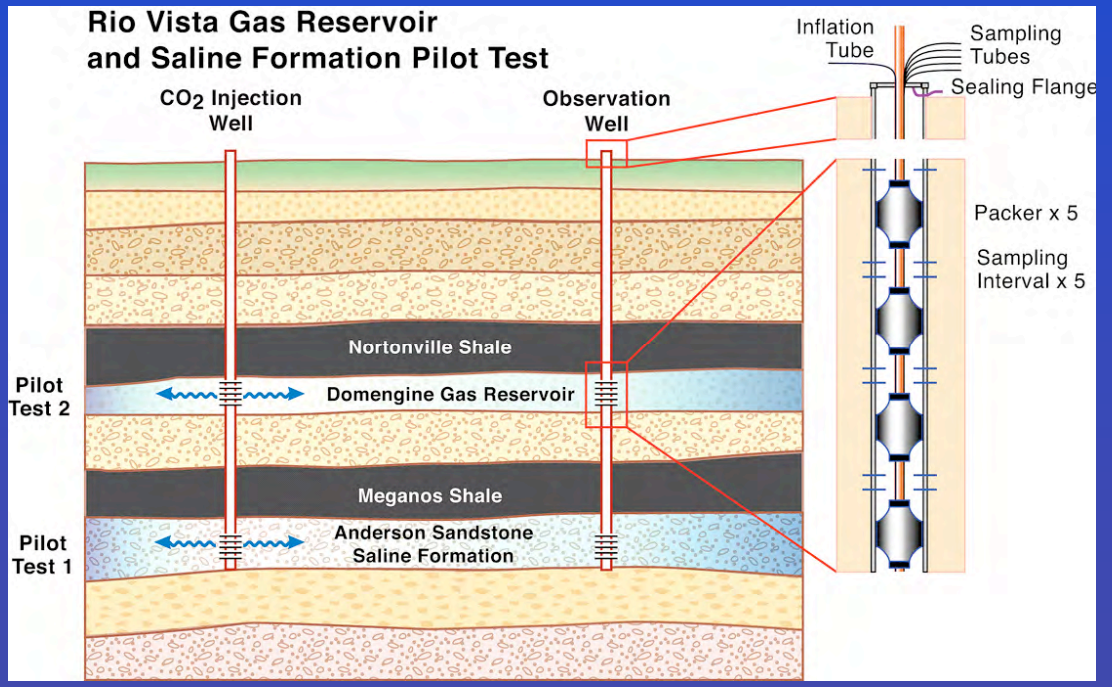




EOR Can Offset Capture Costs

Pilot Tests of CO_2 Storage in CA





Calpine-Rosetta Pilot Test

Conclusions

- California has significant potential for CCS
- Significant EOR potential could lower the costs for CCS
- Pilot tests will provide valuable experience for full-scale implementation
- Additional work is needed to characterize saline formation capacity and source/sink matching