

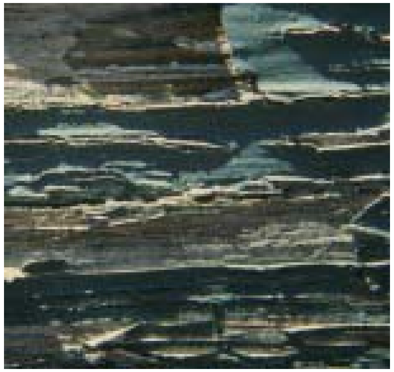

CAN WE RELIABLY AND SAFELY STORE LARGE AMOUNTS OF CO2 UNDERGOUND AS A CLIMATE CHANGE STRATEGY?

Presented by:

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Presented to:

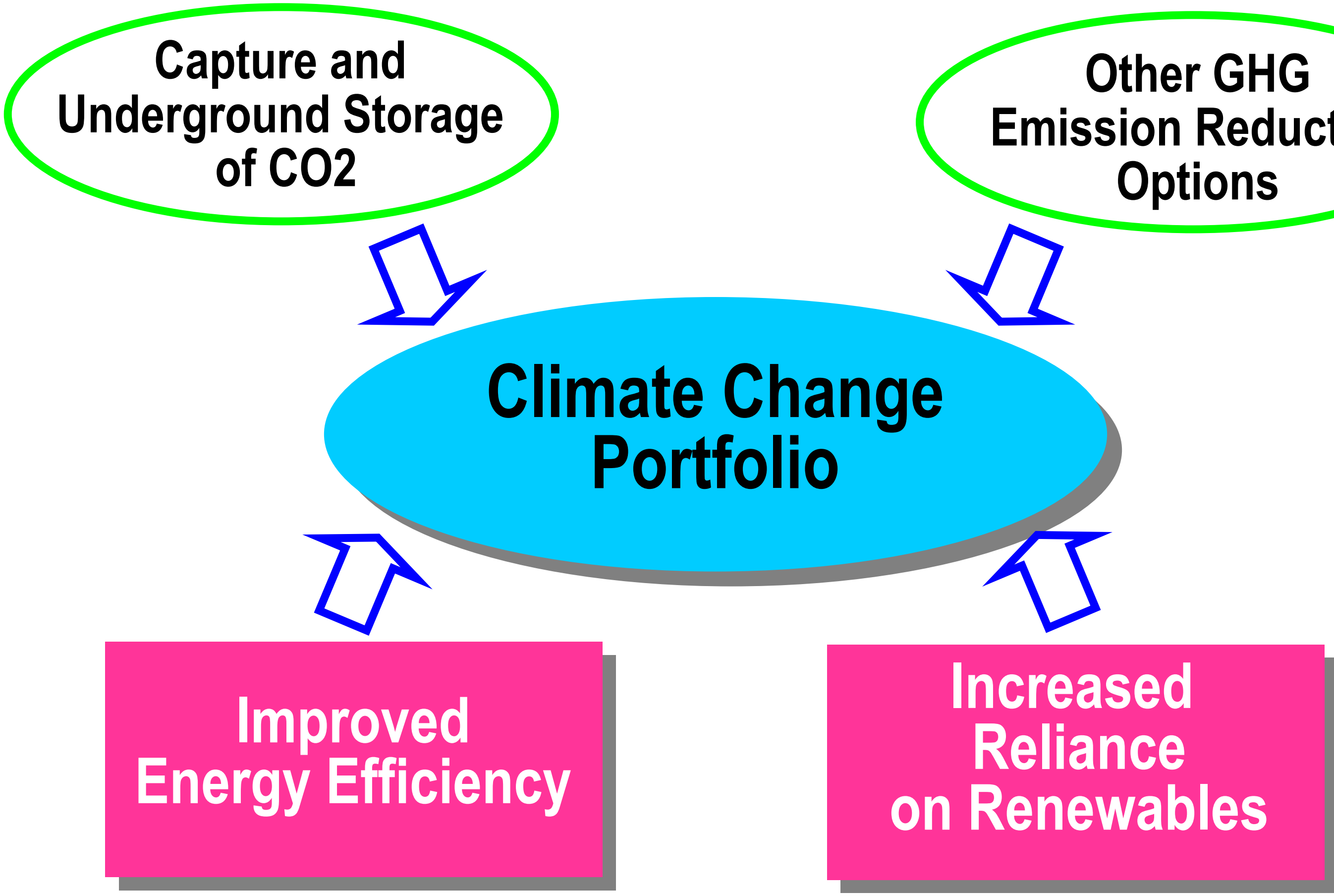
Fourth Annual SECA Meeting

Seattle, WA

April 2003

A PORTFOLIO OF CLIMATE CHANGE STRATEGIES

1. UNDERGROUND STORAGE OF CO_2 IS ONE <u>ASPECT OF A CLIMATE CHANGE STRATEGY</u>



WHY CONSIDER UNDERGROUND STORAGE OF CO2?

2. UNDERGROUND STORAGE OF CO2 OFFERS LARGE POTENTIAL BENEFITS

- Lower Costs
- Relatively Near-Term Strategy
- Large Potential
- Balances Energy Security and Economic Growth

HOW LARGE AND CENTRAL WILL BE ITS ROLE?

To determine the role of CO_2 capture and storage as a climate change strategy, we need to address four questions.

1. ***Will the costs of CO_2 capture and storage be affordable and competitive with other climate change mitigation options?***
2. ***Is there sufficient capacity to store large amounts of CO_2 underground?***
3. ***How strong is our experience with safely transporting and storing large volumes of CO_2 underground?***
4. ***What must be done to assure that underground storage of CO_2 is reliable and safe, sufficient to gain public acceptance?***

Figure 1. OBJECTIVES AND PARTICIPANTS OF THE CCP

CO_2 Capture Project

CO_2 Capture Project

- Achieve major cost reductions in CO_2 Capture and Storage:
  - 50% reduction for retrofit applications.
  - 75% reduction for new builds.
- Demonstrate to external stakeholders that CO_2 storage is safe, measureable, and verifiable.

bp | ChevronTexaco | EnCana | Eni | Hydro | Shell | Statoil | Suncor Energy

US Department of Energy | European Union | Klimatek NorCap

Table 1.
HIGH CONCENTRATION SOURCES OF CO_2 EMISSIONS*

Industrial Source	Estimated Annual U.S. Emissions (2000) (Million t C)	(Million t CO2)
Oxygen-blown Gasification	15	55
Cement Manufacturing	11	40
Natural Gas Processing	5	19
Ammonia Production	4	15
Hydrogen Units at Refineries	4	15
Ethanol/Power Production	1	4
TOTAL	40	148

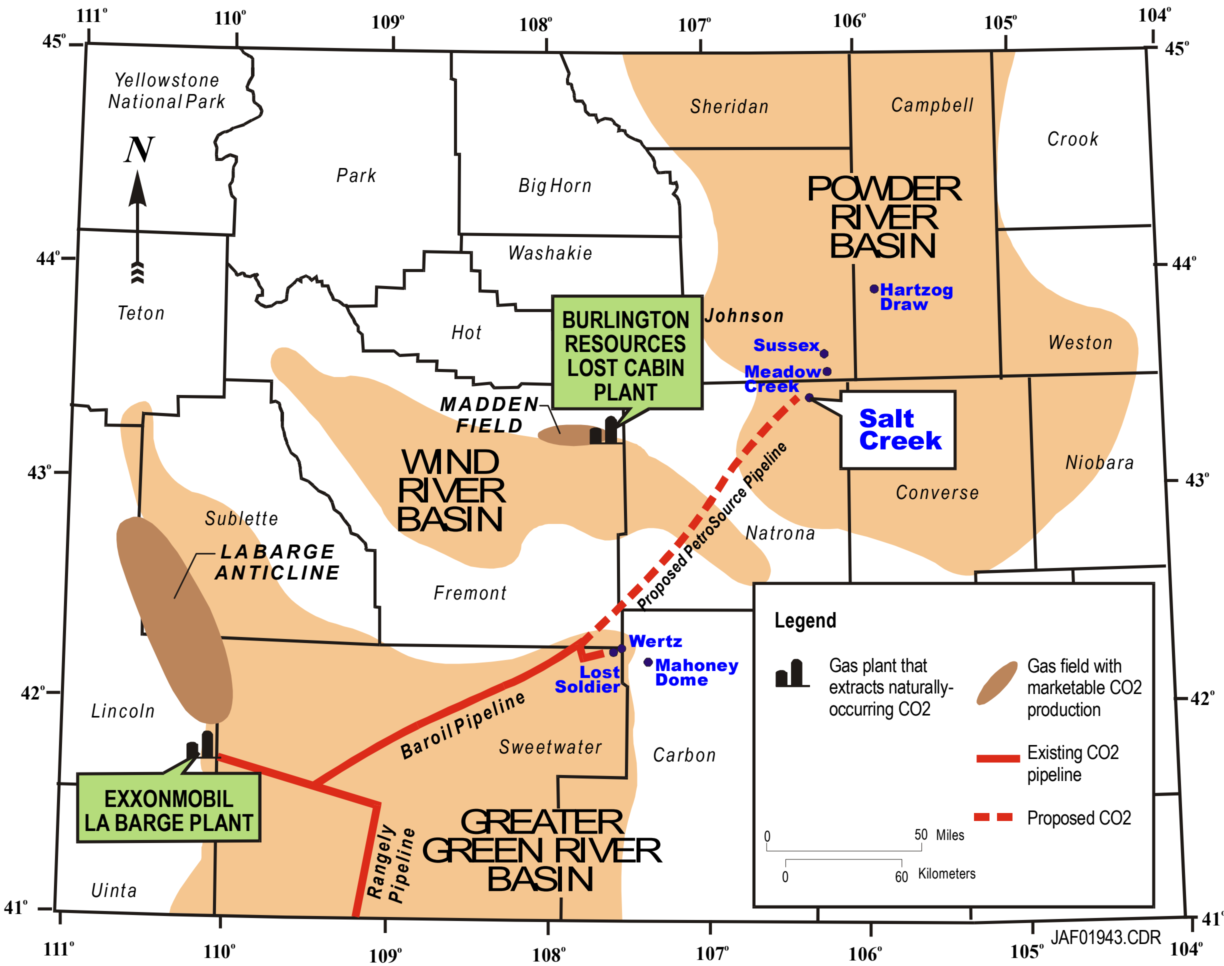
**Oxygen-blown gasification units allocated by industry.*
Source: Internal working papers.

Table 2.
CO_2-EOR PROJECTS SEQUESTERING ANTHROPOGENIC CO_2

State/ Province	Plant Type	CO_2 Supply		EOR Fields	Operator
		MMcfd	Million t/Yr		
SASKATCHEWAN	Coal Gasification	95	1.8	Weyburn	PanCanadian
OKLAHOMA	Fertilizer	35	0.7	N.E. Purdy, Bradley Unit, Sho-Vel-Tum	Anadarko, Chaparrel Energy
COLORADO	Gas Processing	60	1.2	Rangely	ChevronTexaco
TEXAS	Gas Processing	70	1.3	Sharon Ridge, Others	ExxonMobil
WYOMING	Gas Processing	30	0.6	Lost Solider, Wertz	Merit Energy
ALBERTA	Ethylene Plant	4	0.1	Joffre Viking	PanWest Petroleum
TOTAL		**294**	**5.7**		

Source: Advanced Resources International, 2003

Figure 2. CO_2 FACILITIES AND EOR FIELD SITES, WYOMING



Source: Carbon Dioxide in Wyoming, WY State Geological Survey, Info Pamphlet 9, 2001

INCENTIVES FOR CO_2 STORAGE AND DOMESTIC ENERGY PRODUCTION

Market-based incentives would be structured to encourage industry to capture high CO_2 concentration emissions for enhanced oil, natural gas and coalbed methane recovery:

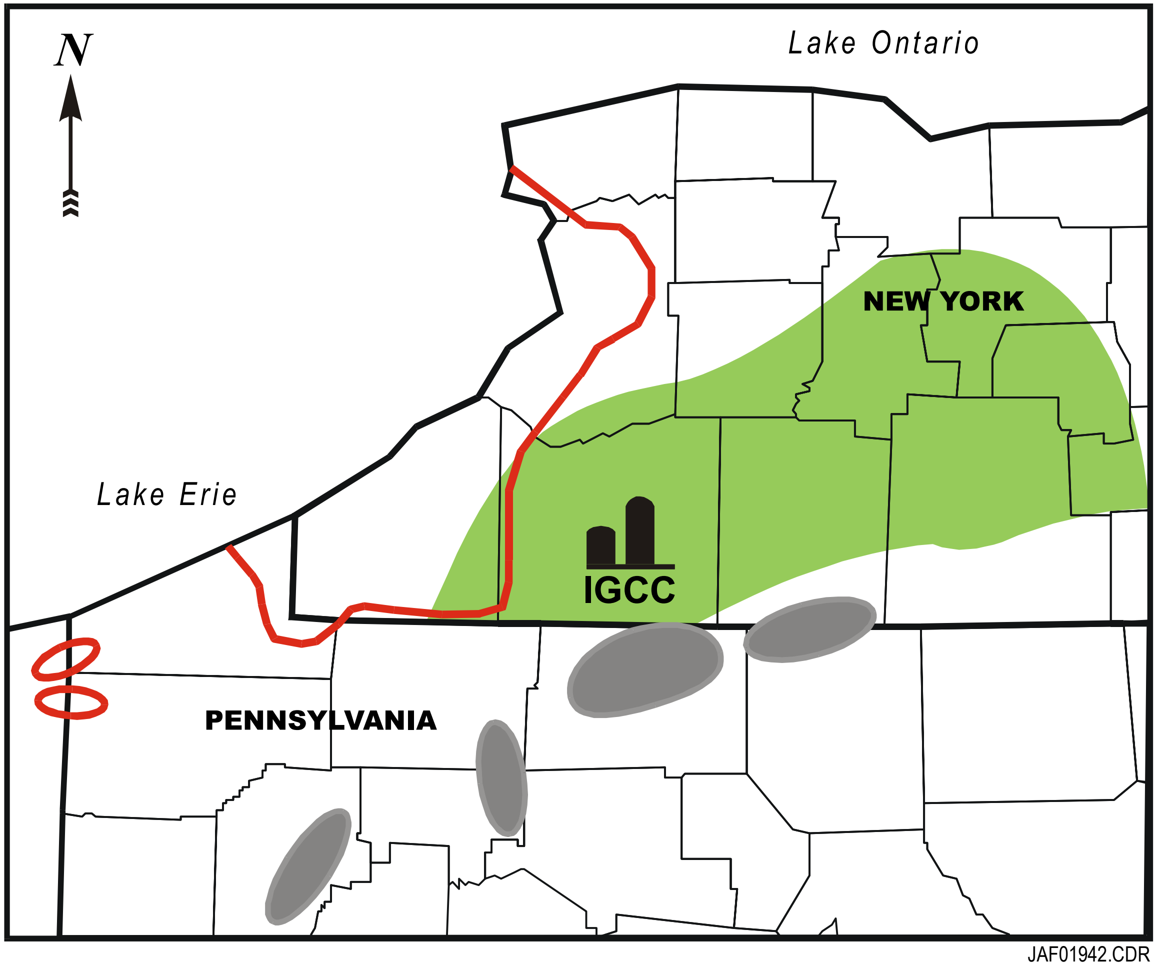
- **Low-cost capture of CO_2 emissions**
- **Production of additional domestic energy**
  - **1 million barrels per day of oil production**
  - **Substantial potential for additional natural gas reserves**
- **A \$50/tonne carbon (\$13 to 14/tonne CO_2) sequestration credit would be revenue neutral.**

Table 3.
CO_2 STORAGE CAPACITIES OF U.S. GEOLOGIC FORMATIONS

	Estimated CO_2 Storage Capacity (Million Metric Tons)	
	CO_2	Carbon
Unmineable Coal Beds (Lower 48)	50,000	15,000
Depleting Oil Reservoirs	50,000	15,000
Depleting Gas Reservoirs	100,000	30,000
Saline Aquifers	Large	Large
Other	TBD	TBD

Source: Advanced Resources International, 2002

Figure 3. POTENTIAL CO2 STORAGE OPTIONS IN WESTERN NEW YORK AND NORTHERN PENNSYLVANIA



SALINE AQUIFERS

1. **Rose Run** (shown on map)
   - Area bounded by depth, structure and gross sand isopach
   - Holds 2 to 7 Gt CO2
2. **Potsdam** (not shown)

OIL FIELDS

Bradford
Other

GAS FIELDS

Lake Shore
(Clinton-Medina)

CONVERTING CURRENT EOR PRACTICES TO CO_2 STORAGE

1. **Assess and configure reservoir for long-term (~1,000 year) storage of CO_2.**
2. **Maintain CO_2 in reservoir (at pressure) rather than "blow down" reservoir and reuse the CO_2.**
3. **Install long-term monitoring, verification and safety systems.**

Figure 4. STATUS OF CO_2-EOR IN THE U.S.

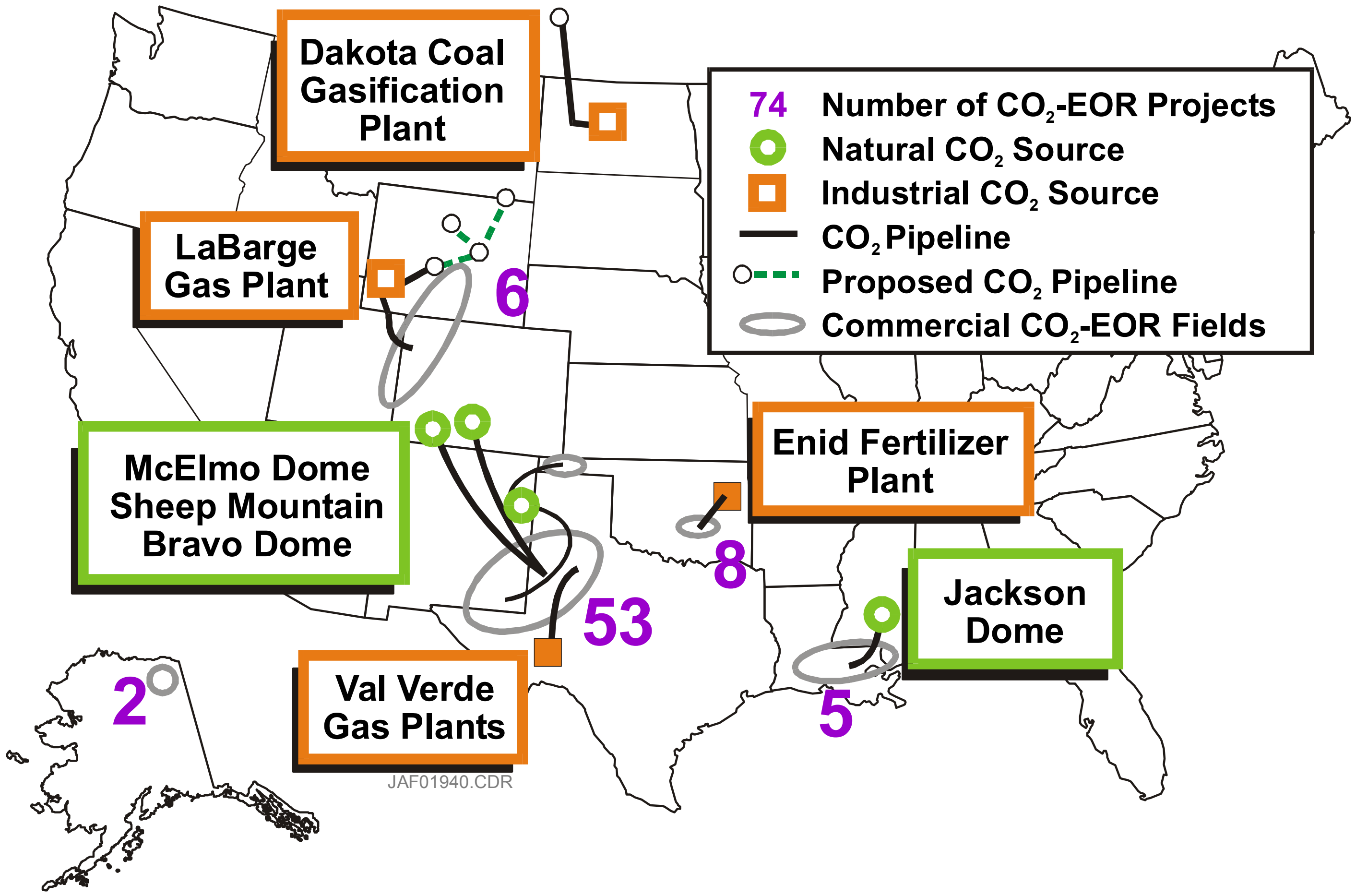
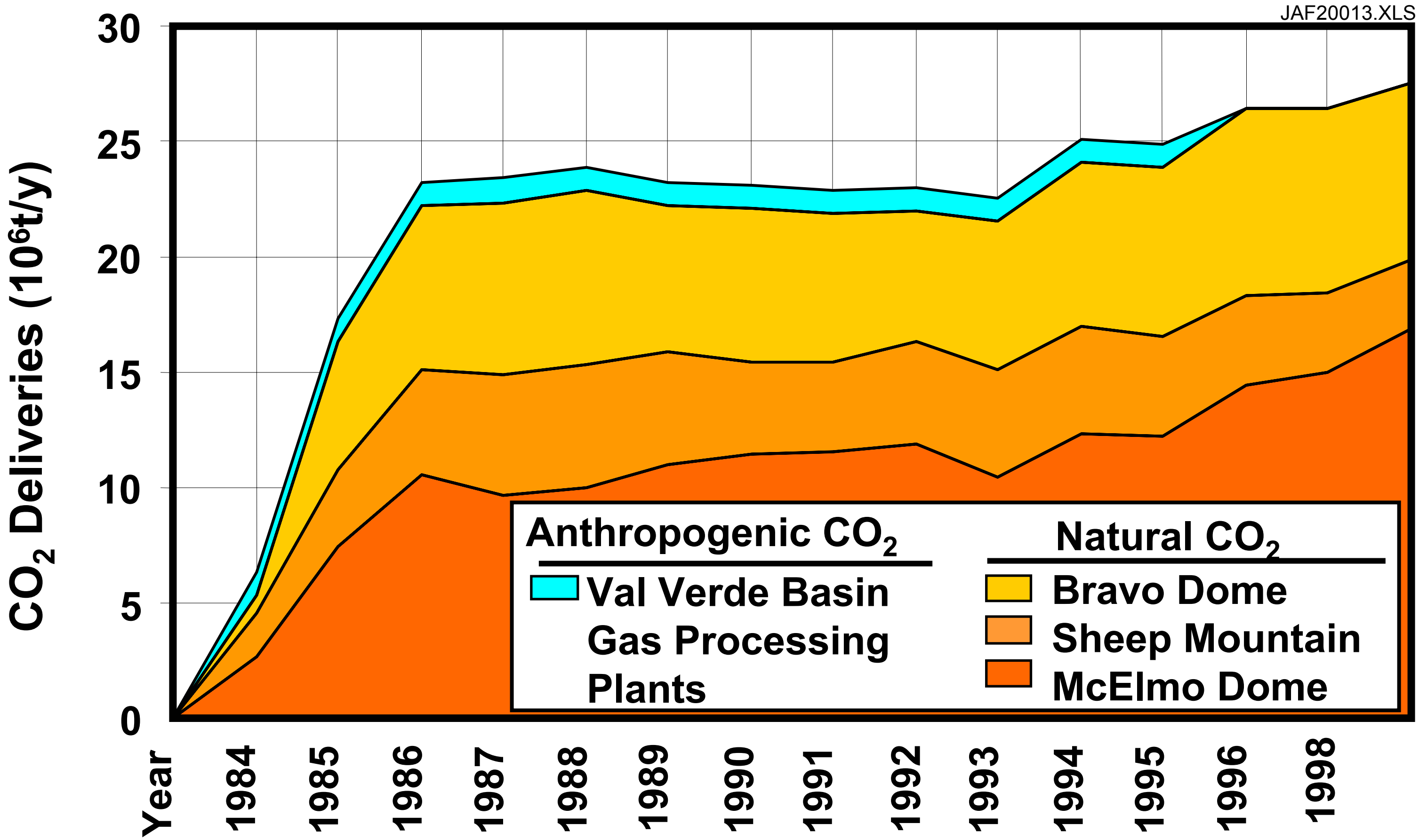


Figure 5. PERMIAN BASIN CO2-EOR PROJECTS



Source: Shell CO_2 Company

Figure 6. CO_2 –EOR PRODUCTION IN THE U.S.

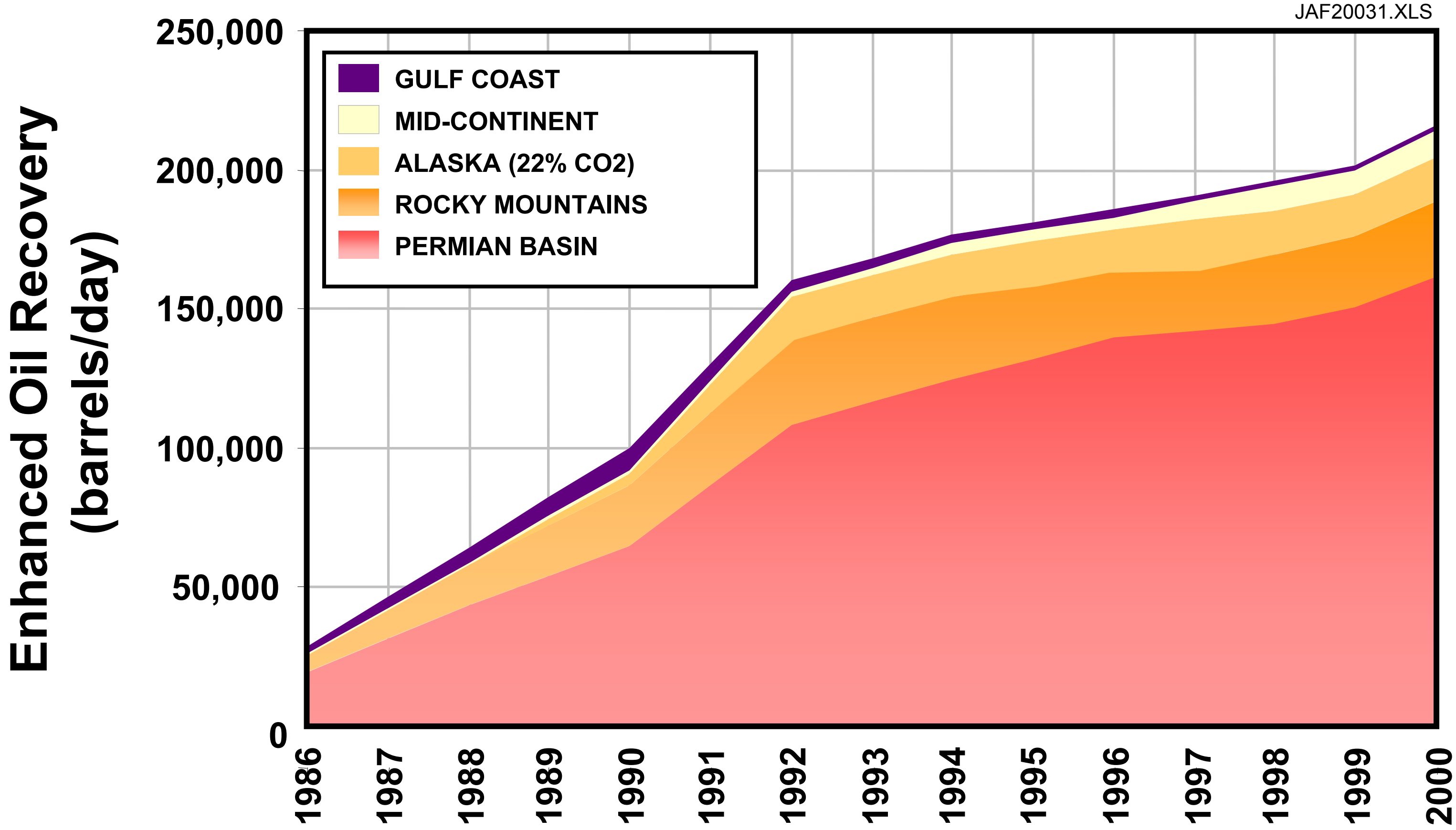


Figure 7. LOCATION OF ECBM PILOTS, SAN JUAN BASIN, USA

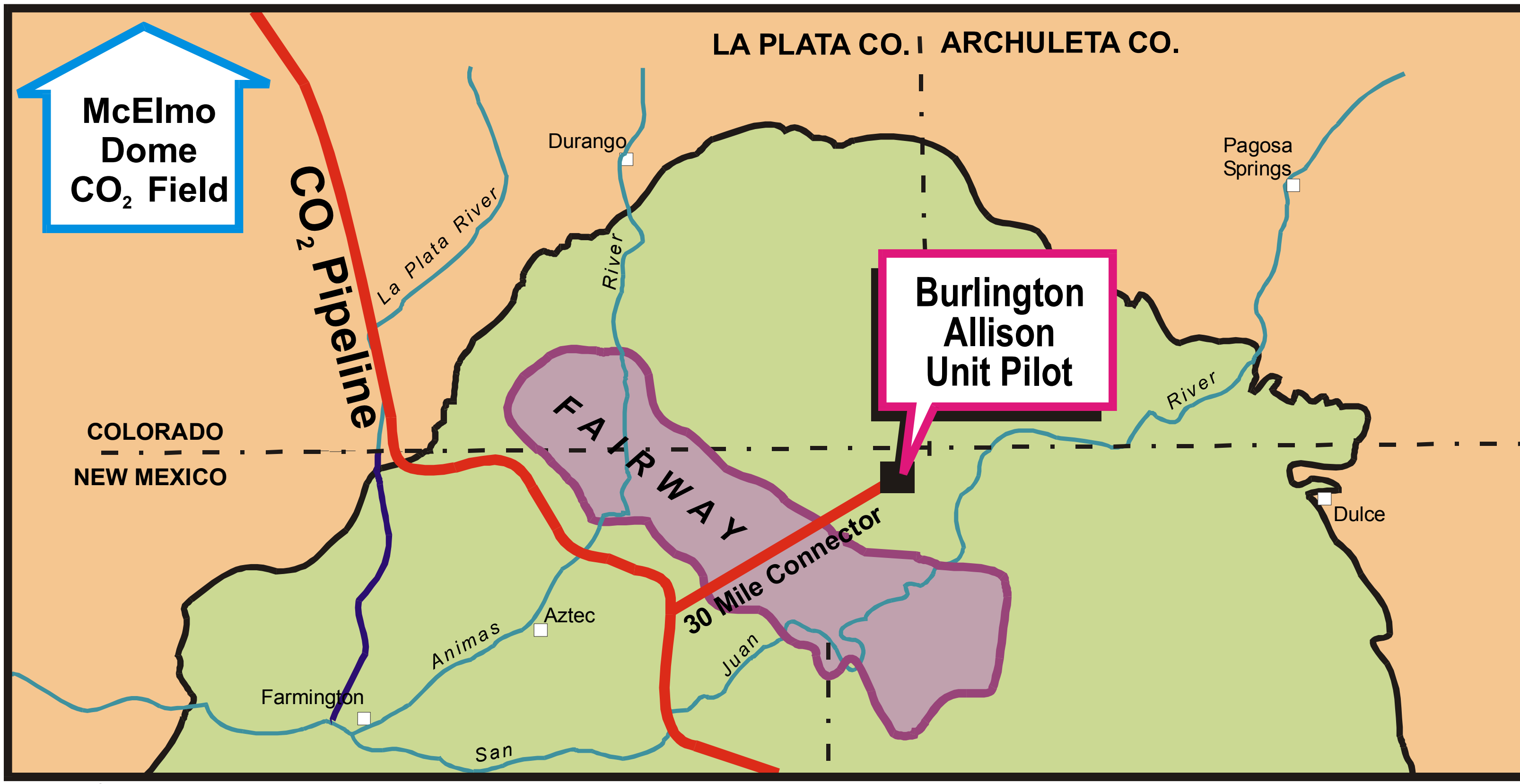


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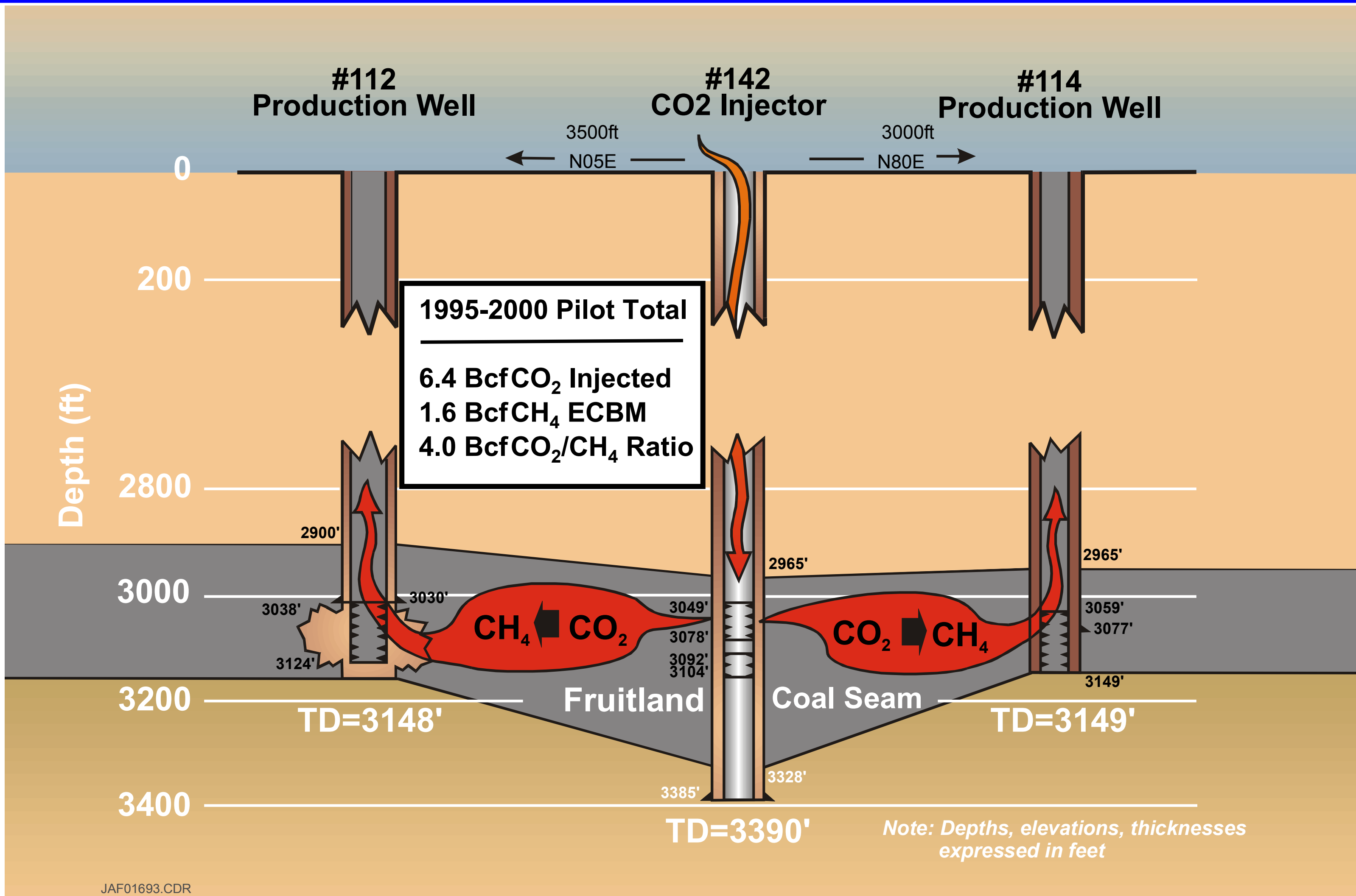
Figure 8. CROSS-SECTIONAL VIEW OF THE ALLISON UNIT CO_2–ECBM PILOT, SAN JUAN BASIN



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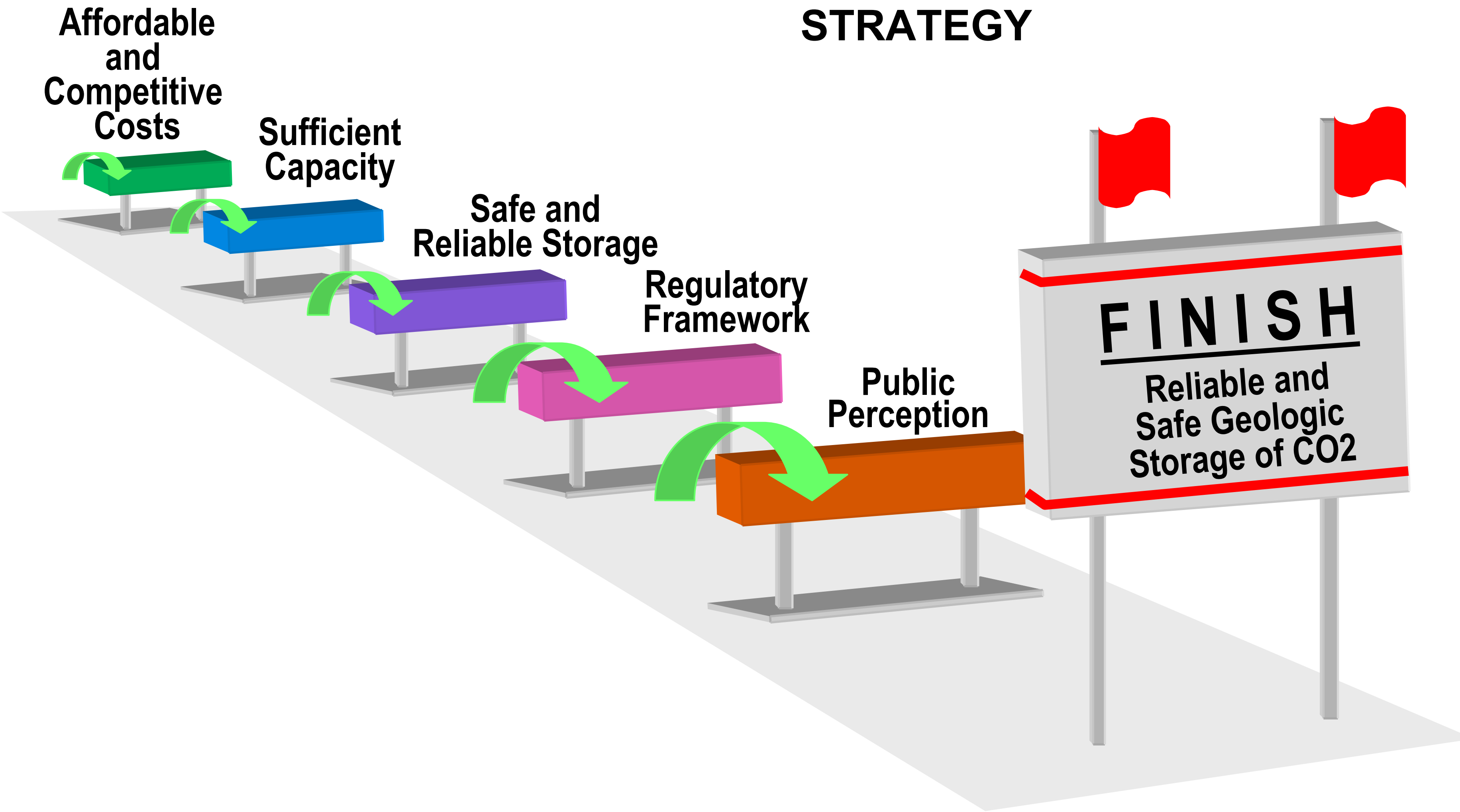
ACHIEVEING SAFE AND RELIABLE UNDERGROUND STORAGE

The greatest challenge facing carbon capture and storage as a climate change strategy will be gaining public acceptance, shaped by the public's perception of its safety and reliability:

- **Understanding of long-term transport of CO2 and its interaction with underground reservoirs**
- **Compelling, scientific case as to its safety**
- **Appropriate regulatory framework**

Figure 9. OVERCOMING HURDLES TO USING CARBON CAPTURE AND STORAGE AS A CLIMATE CHANGE STRATEGY

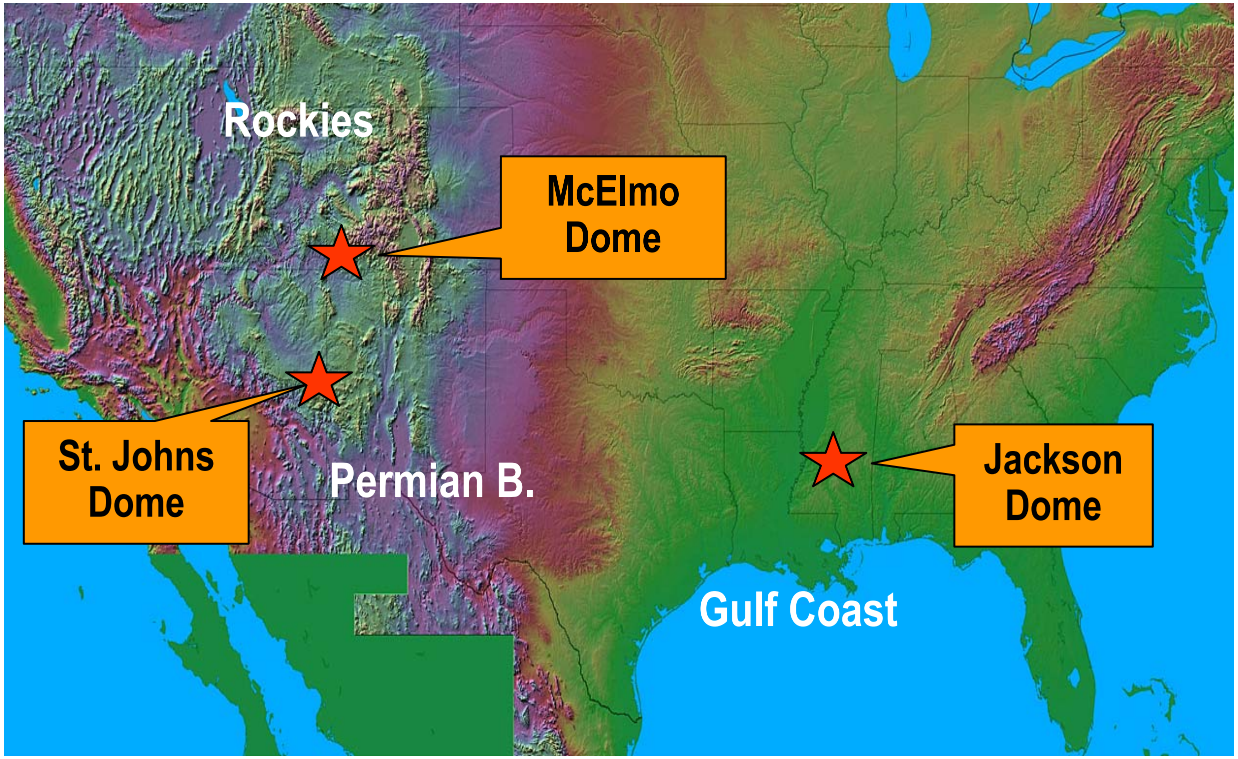


PATH FORWARD FOR CO2 STORAGE

Building the base of scientific knowledge and public acceptance for CO2 capture and storage could follow this "path forward":

1. Learning from nature and its CO2 storage analogs
2. Targeting enhanced oil and gas recovery with high concentration CO2 vents
3. Encouraging zero CO2 emission hydrogen production
4. Partnering with international efforts
   - Sleipner/SACS
   - Weyburn
   - RECOPOL

Figure 10. NATURAL CO2 FIELDS AS ANALOGS FOR GEOLOGIC SEQUESTRATION



McELMO DOME

- Charged with CO_2 millions of years ago; holds nearly 2 Gt of CO_2.
- CO_2 reservoir capped by 1,500 feet of impervious salt and another 5,000 feet of shale and sandstone.
- Oil and gas explorations wells show the overlying strata to be CO_2 free (with one exception).
- Overlying salt is self-healing for faults and seismic activity.
- Two decades of safe CO_2 production and transportation.

SUMMARY

- **Acceptability of underground storage of CO2 will rest on a scientific and public balancing of risks.**
- **The prevailing scientific and industrial view is that underground storage of CO2 has a low risk of causing significant harm, assuming:**
  - **Suitable reservoirs are selected**
  - **Proper procedures are followed**
- **The compelling case for its safety and reliability still needs to be made to gain public acceptance:**
  - **Sound, transparent research**
  - **Straight-forward communication**

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