Southwest Regional Partnership on Carbon Sequestration

Utah Geologic Sequestration Tests

Project Overview

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Pittsburgh, Pennsylvania

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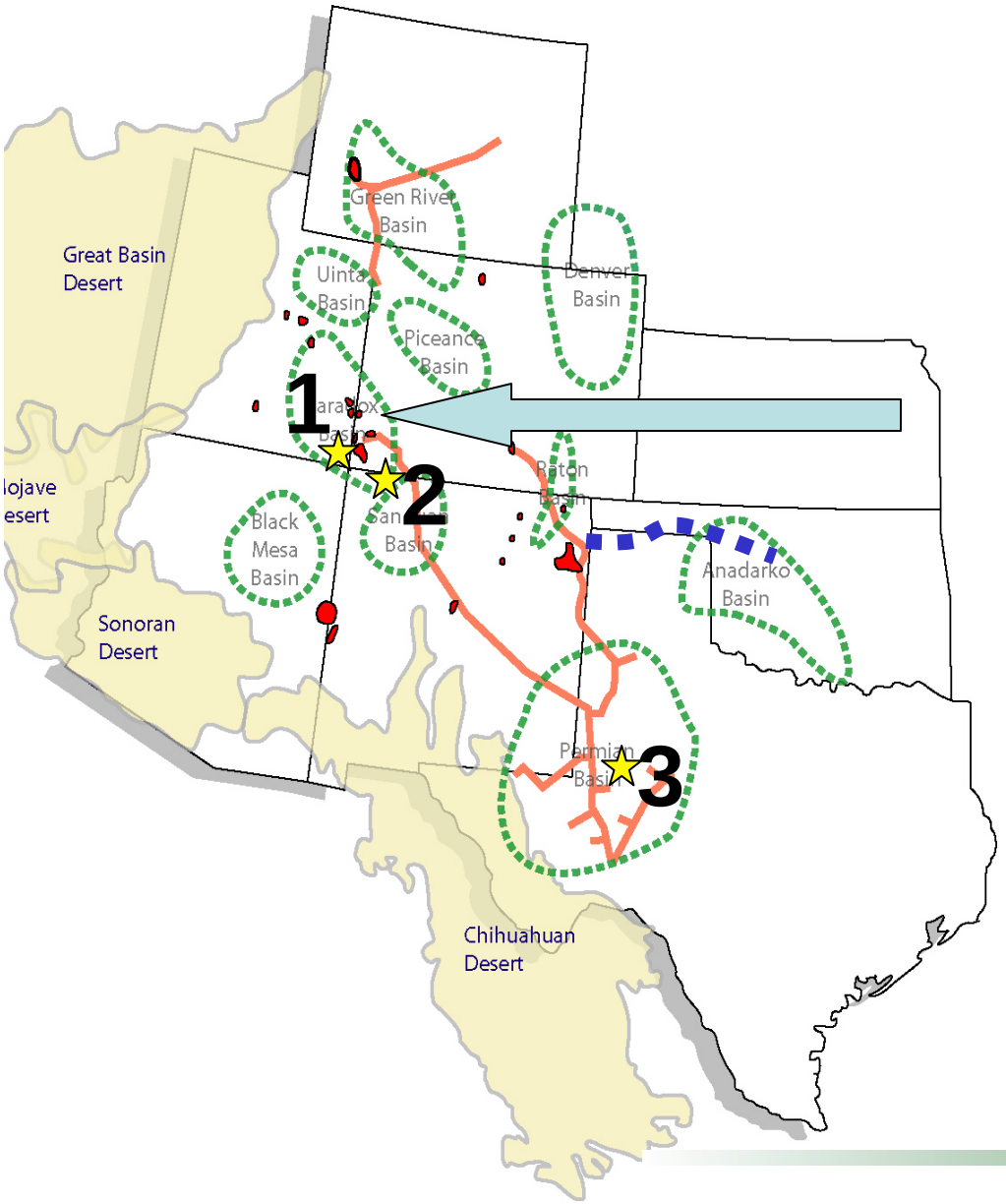
Utah Sequestration Tests



Utah was one of several sites selected as the most promising for testing in Phase II:

- combined EOR and deep saline sequestration testing, Paradox Basin, Utah

Aneth, Utah: Two Demonstrations

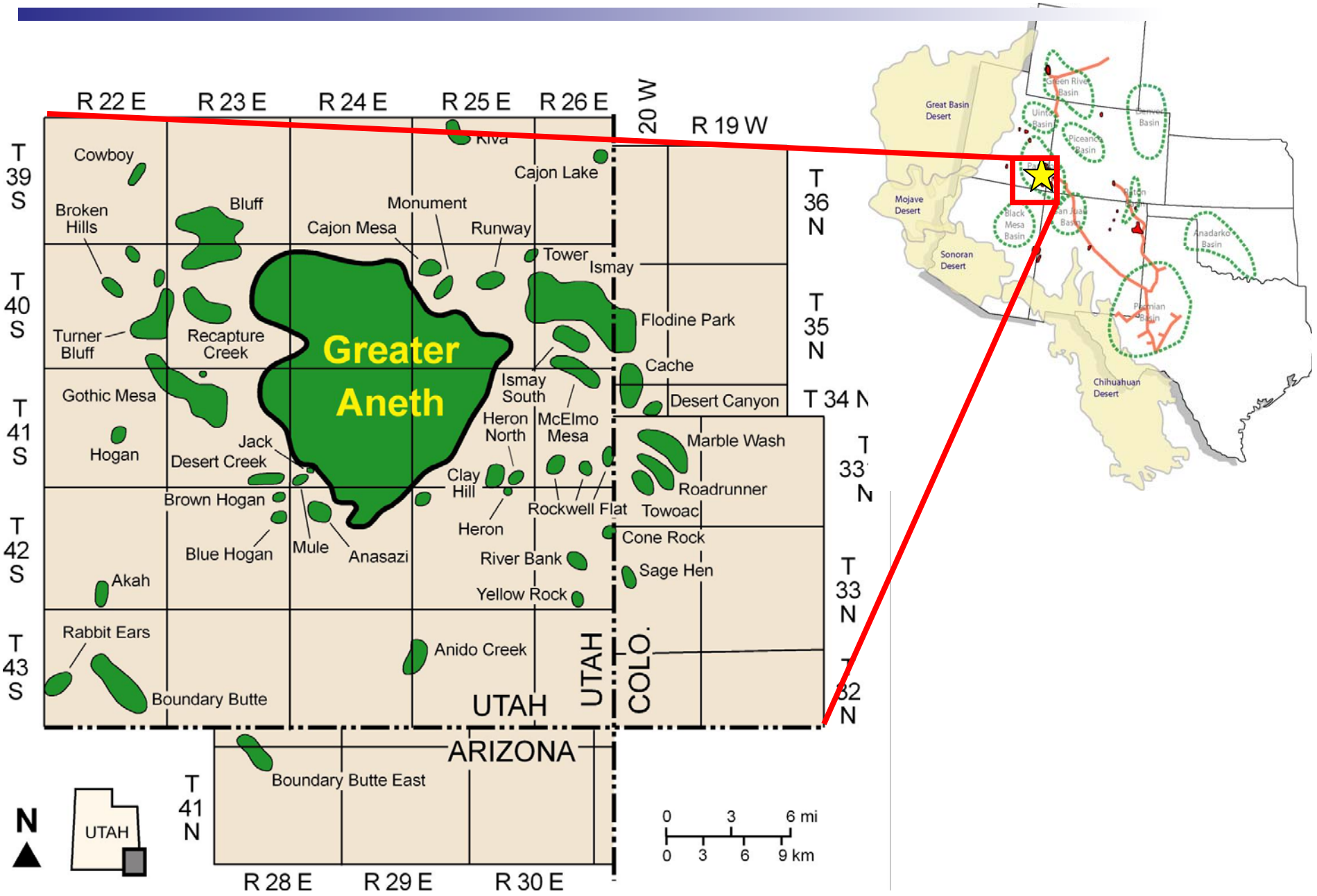
Deep saline reservoir demonstration

- small-scale injection (20,000 tons)
- Permian-aged sandstone unit, representing a regional target throughout the Southwestern U.S.

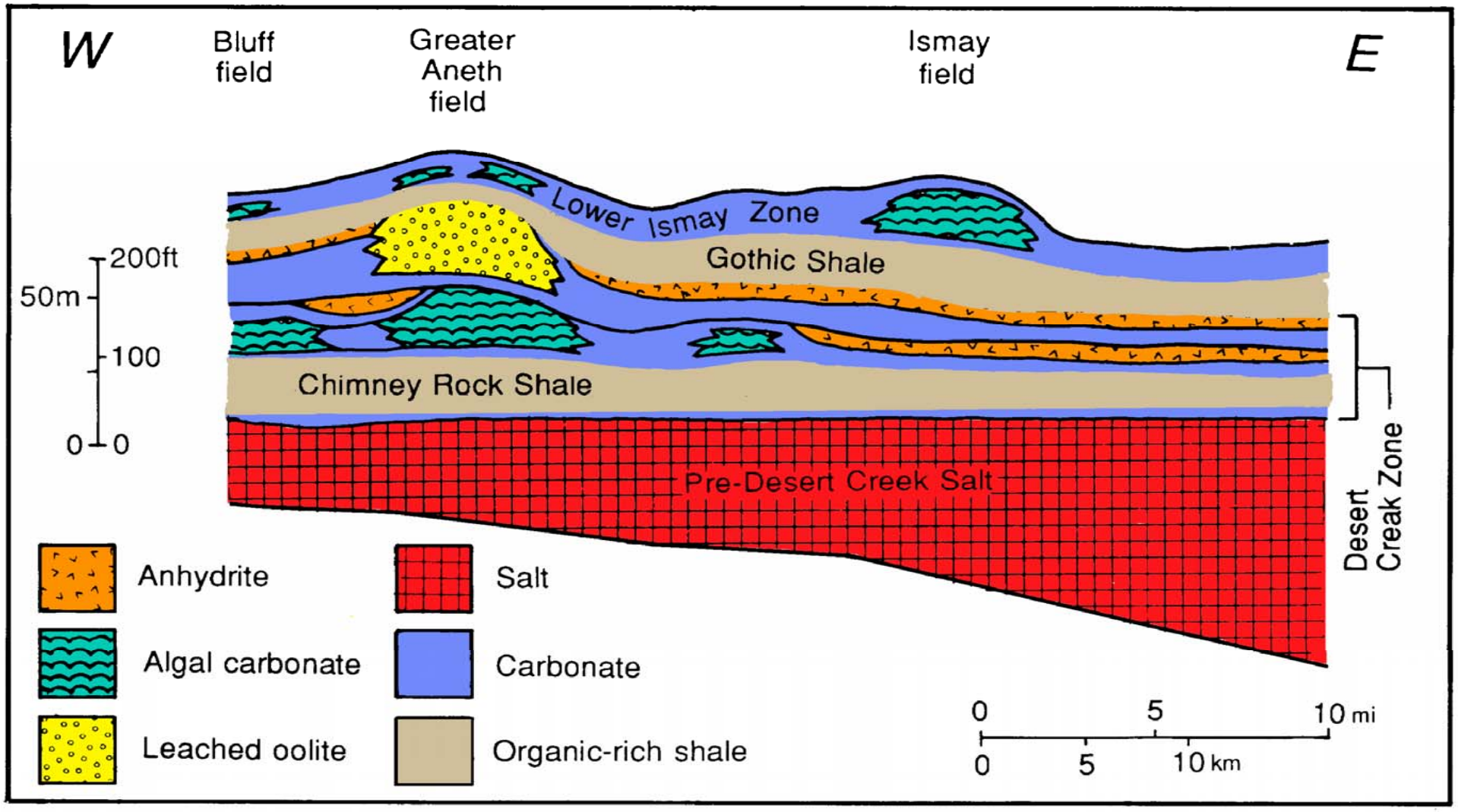
- **EOR - sequestration demonstration**
  - "tired" reservoir (Desert Creek Fm.)
  - medium-scale injection (150,000 tons/year for 3 years)

Photo from Resolute Natural Resources

Aneth, Utah: Two Demonstrations



Site Description: General Geology



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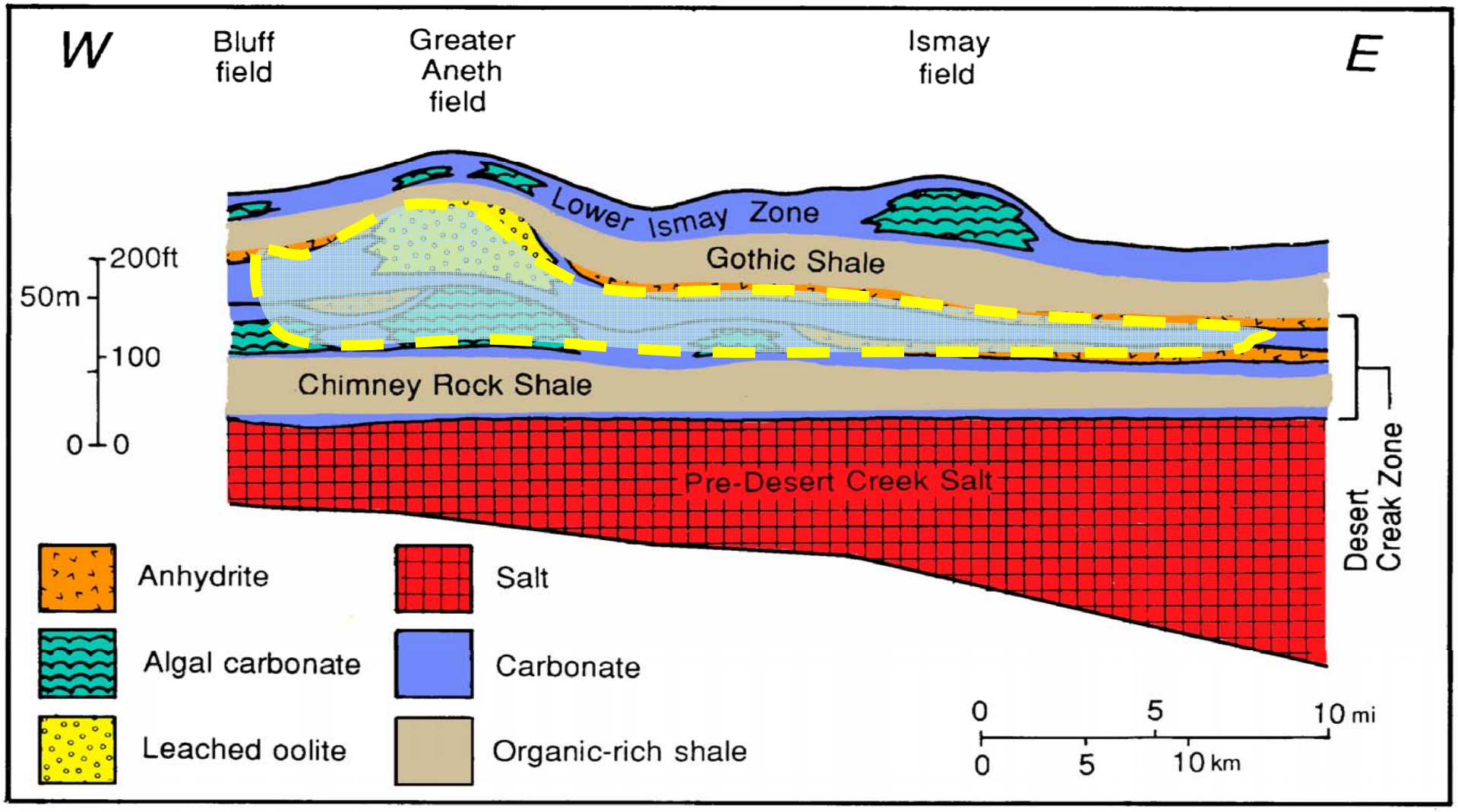

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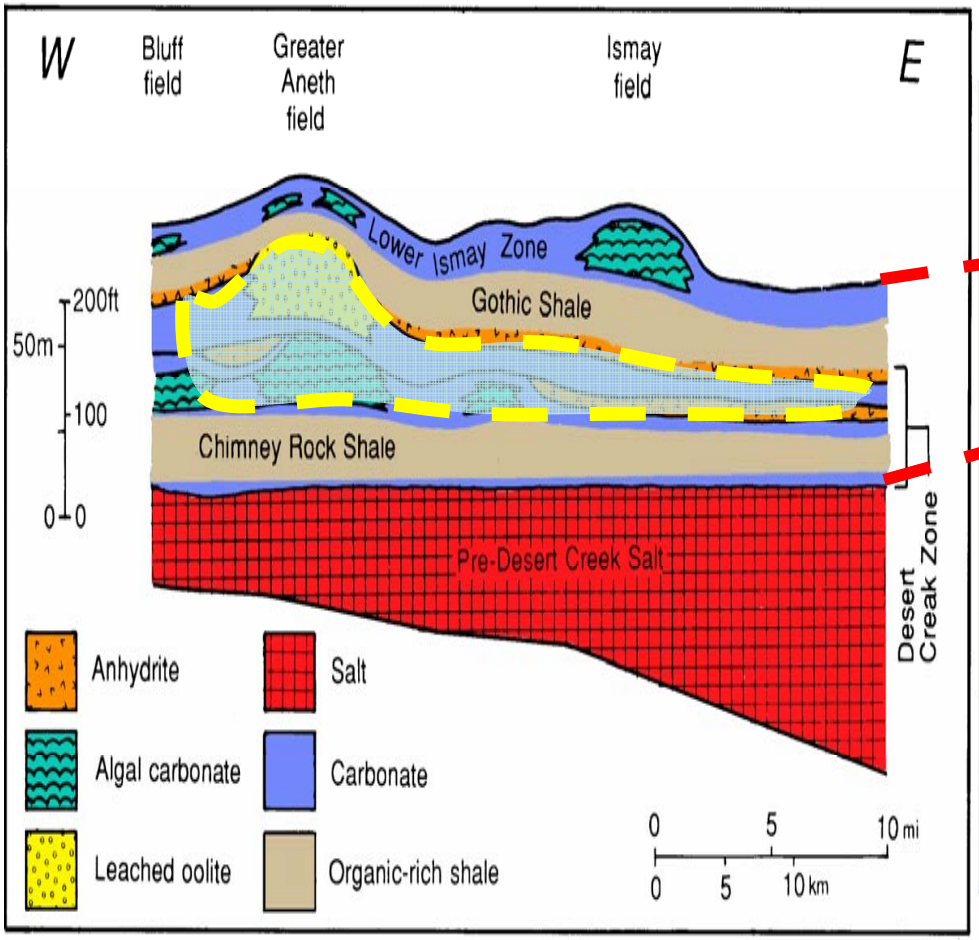
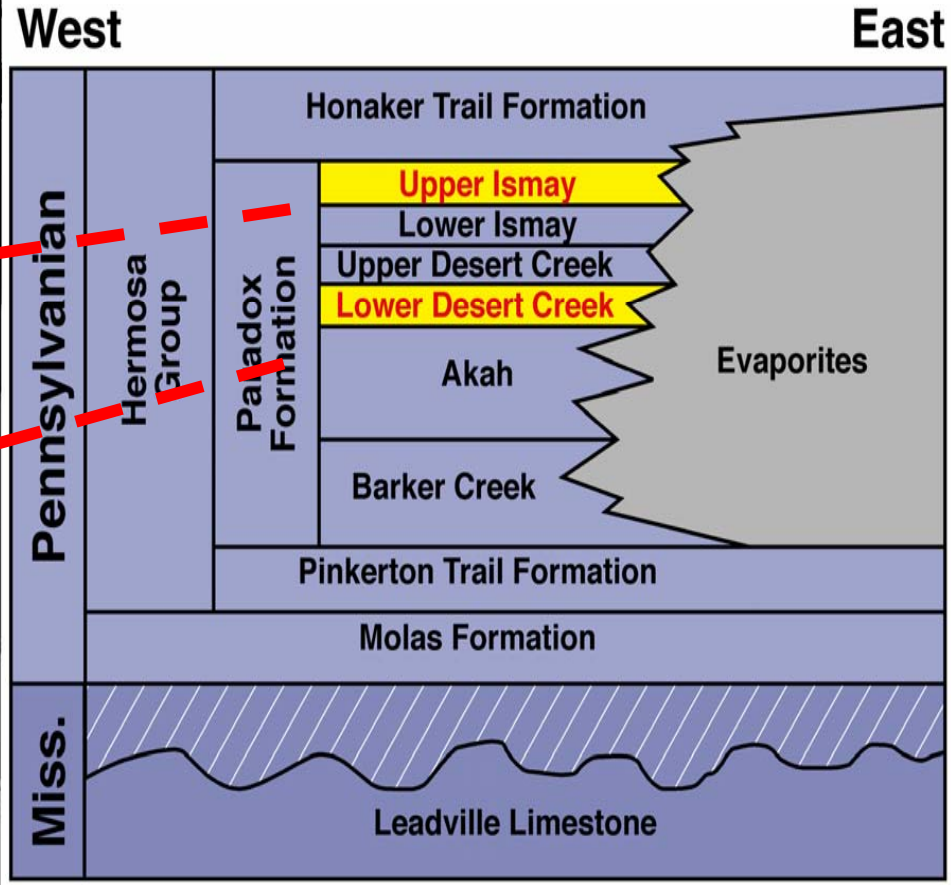




Site Description: Field History

- Aneth field discovered in 1956 by Texaco
- Greater Aneth field unitized in 1961
- Waterflood commenced in 1962
- Downspaced to 40 acres in 1970s
- Aneth pilot CO_2 program in 1998
- Peak rate ~100,000 BOPD, current rate ~10,000 BOPD

Major Aneth Tasks and Timeline

- Original pilot CO_2 flood in 1998
- Construction of new pipelines (water and CO_2) and new facilities construction began in March 2006
- CO_2 first phase of main reservoir injection to begin in January, 2007
- Smaller-scale, deep Permian-aged saline injection will likely begin in May, 2007
- CO_2 expansion injection stages 2 and 3 (in different parts of field) to begin March, 2007

Land Ownership = Constraints

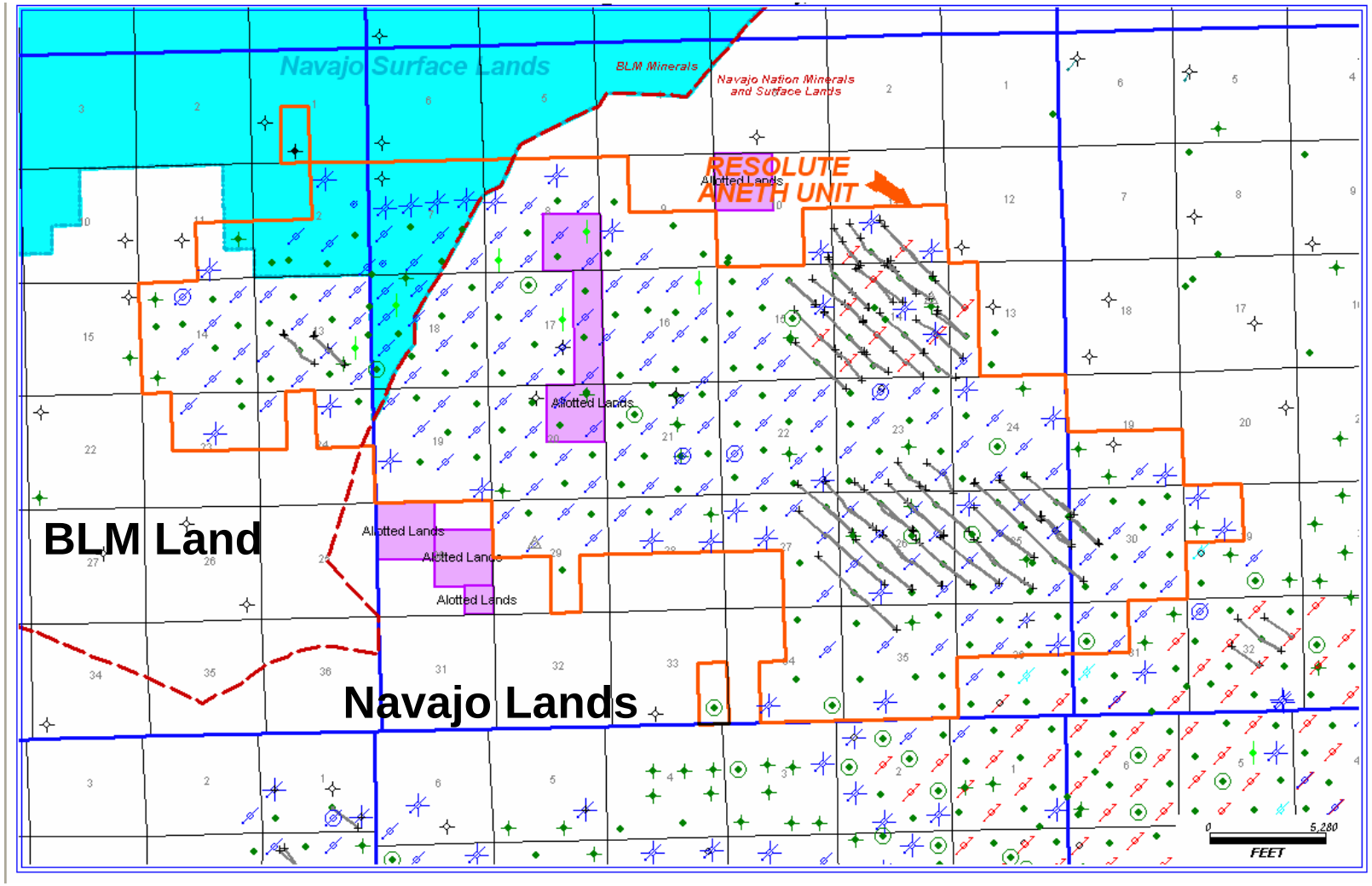


Figure from Resolute Natural Resources

McElmo Creek Unit CO_2 Injection Plant

McElmo Creek Unit CO_2 Injection Plant

McElmo Creek Unit CO_2 Injection Well

McElmo Creek Unit CO_2 Pipeline

Land Ownership = Constraints

- In addition to BLM and Navajo lands which will primarily dictate permitting requirements, there are 30 - 40 homes located within the field area.
- An apparent general distrust of oil operations prevails, with little local knowledge of what oil and CO_2 operations actually involve
- Must exercise cultural awareness and foster communication

General Monitoring Technologies Planned

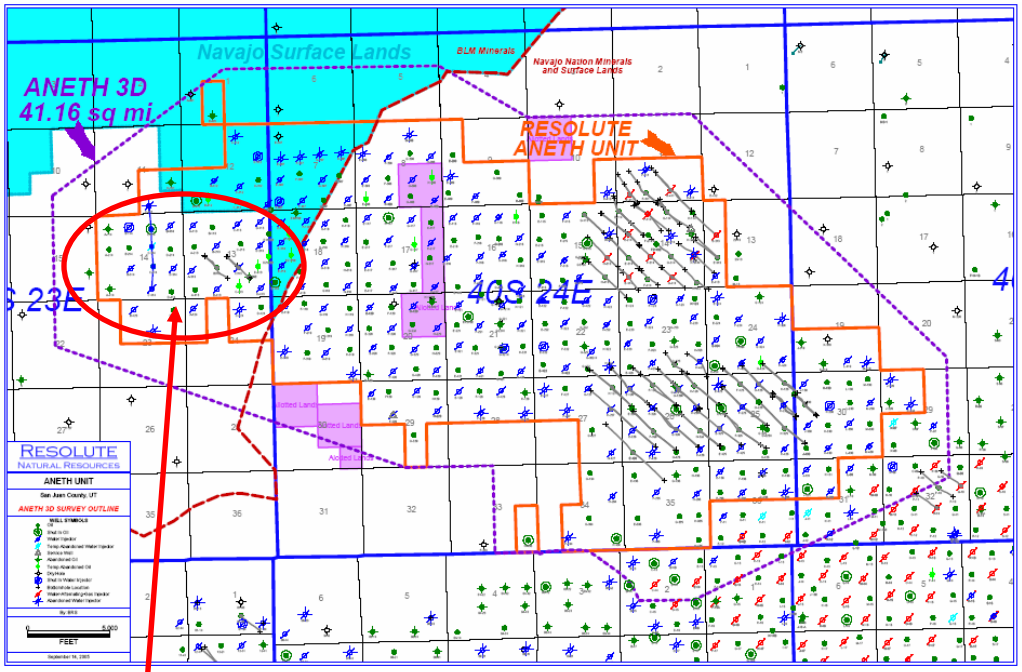
(1) Methods for Detecting CO_2 in non-Target Reservoirs:

- Groundwater chemistry (non-target reservoirs)
- Surface CO_2 chamber flux
- Shallow CO_2 "piezometers" for sub-bio flux
- Remote sensing / LandSat Imaging
- Coupled process reservoir modeling

(2) Methods for Tracking CO_2 Migration and Fate

- 2-D and/or 3-D seismic reflection imaging surveys
- VSP + Active Doublets imaging
- Crosswell seismic imaging
- Passive seismic monitoring/imaging
- Groundwater chemistry (target reservoir)
- In situ pressure, temperature measurements
- In situ bicarbonate detection
- Coupled process reservoir modeling

General MMV Plan: Utah Site



BLM Land

Receiver line

Emphasis:
2-D seismic

165’

Shot lines (40’deep)

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Aneth, Ut: 2007 to 2009

Baseline Background:

- Jun 06: 3D seismic, passive, VSP, crosswell, active doublet
- Mar 06: water chem, gas fluxes
- Monthly before injection: water chem, gas fluxes, remote sensing
- Characterize and measure all wells (plugged or not) in area

During Injection (starts Jan 07)

Bi-monthly: Water chem, gas fluxes, remote sensing, passive seismic

- Every 4-6 months: other seismic
- Carefully monitor other wells
- Constant P-T-bicarb

About Seismic Imaging Plans for Utah

- Very limited budget
- Repeat seismic surveys needed

About Sequestration in the Long Run

- Very limited budget
- Repeat seismic surveys needed
- Frequent repeat surveys likely required

Southwest Carbon "Theme" for Seismic:

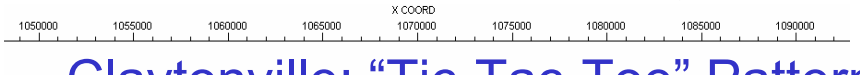
- Results from the Weyburn project suggest that 4-D seismic imaging is effective

- Results from the Weyburn project suggest that 4-D seismic imaging is expensive (!)

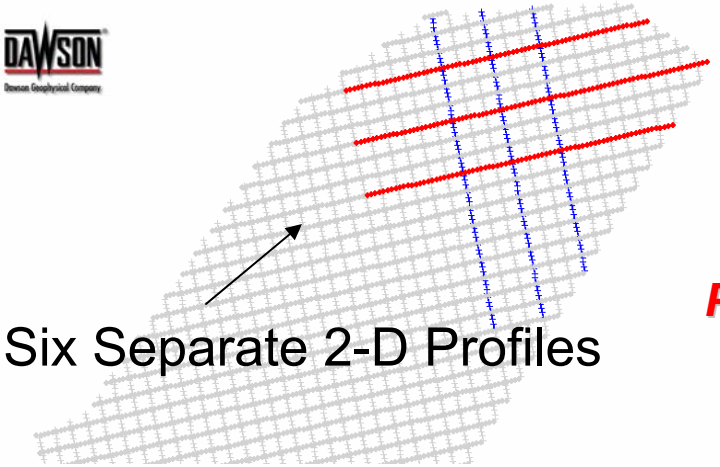
- Thus, a proposed "theme" for now & long-term: **Optimize less-expensive 2-D methods**

Some Less Expensive Seismic Alternatives

- Time-lapse 2-D Seismic Reflection
- Variations on Vertical Seismic Profiles
- Passive seismic monitoring
- Active doublet methods
- semi-3D reflection survey aka “Poor Man’s 3-D”
- concepts embraced by Dawson and other industry partners



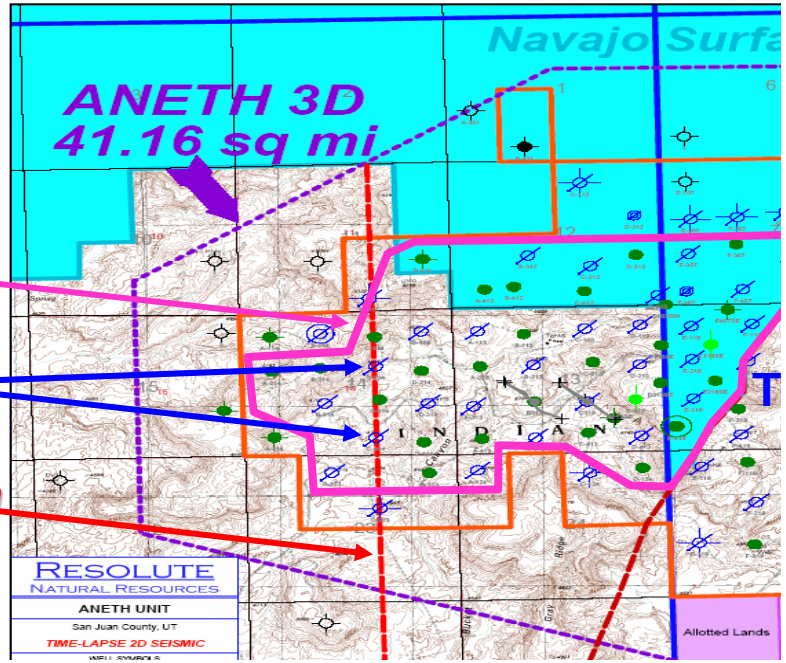
Claytonville: “Tic-Tac-Toe” Pattern



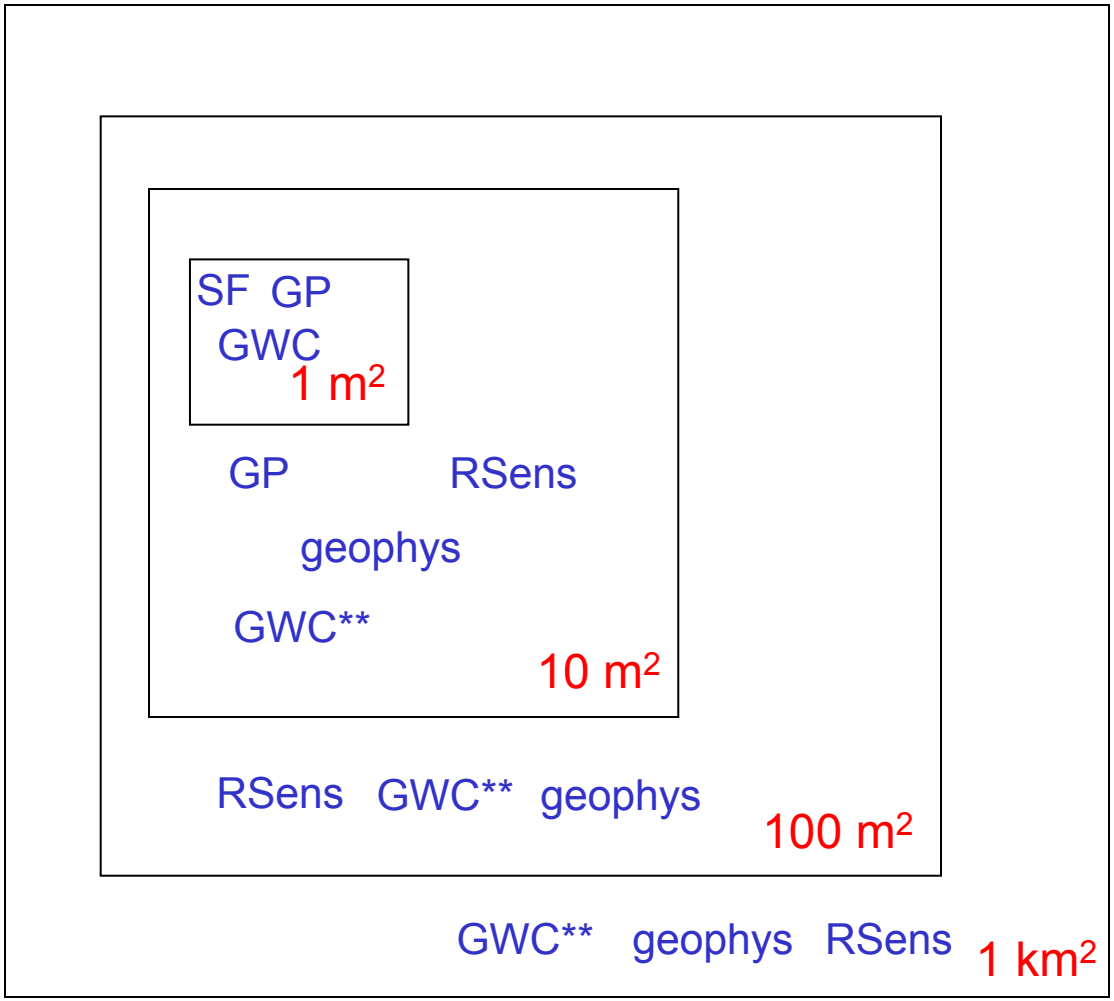
Six Separate 2-D Profiles

Proposed target well(s)

Proposed location time-lapse 2D



Surface Spatial Scales of Monitoring

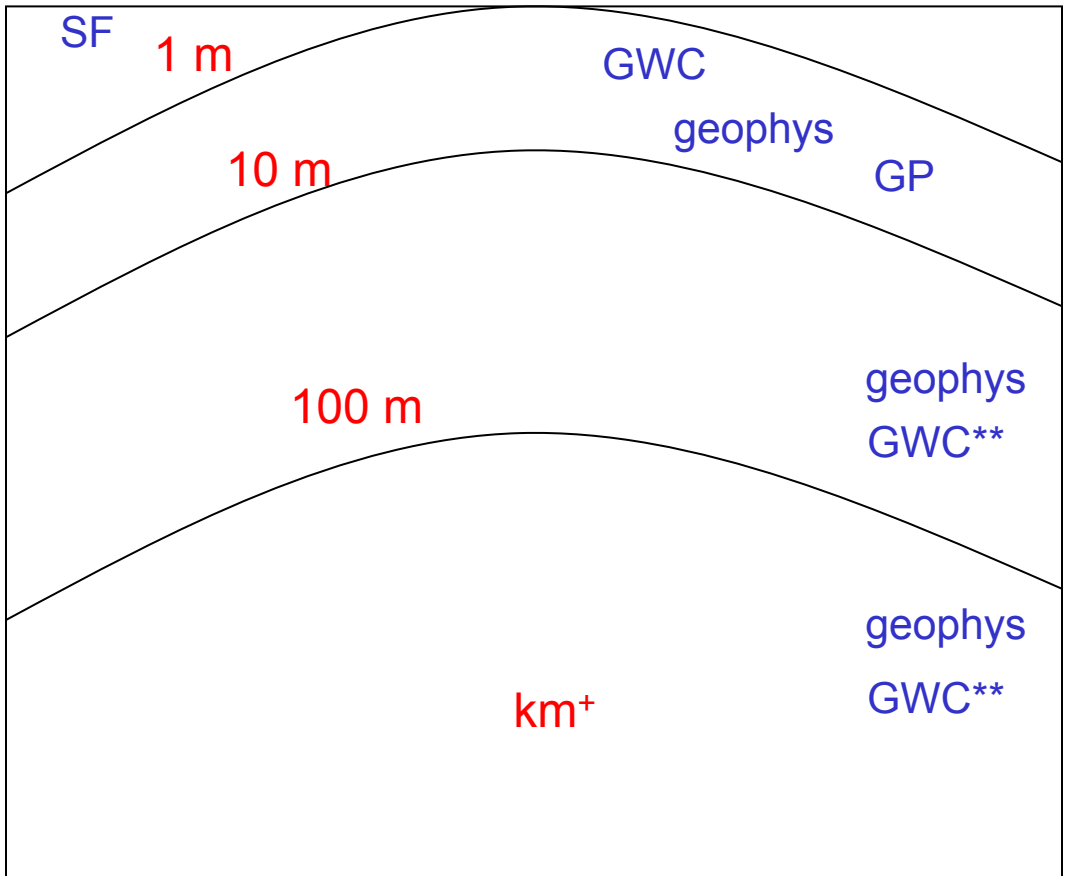


- SF = surface soil gas flux
- GP = gas "piezometer"
- geophys = seismic and other geophysical methods
- GWC = groundwater chemistry and in situ meas
- RSens = remote sensing technologies

***depending on wells available*

Special Focus: the "Intermediate Zone"

Schematic Cross-Section:



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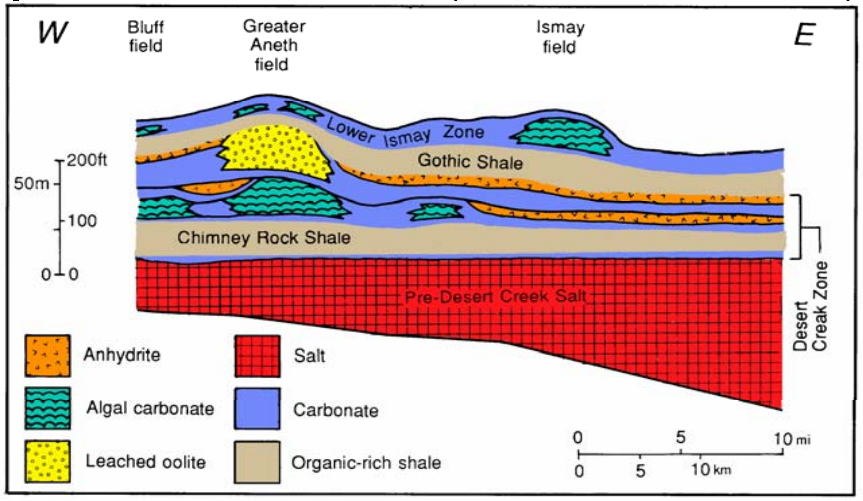
***depending on wells available*

10+ km^2

Poorest resolution (gap):
~30 m to km depth = the "Intermediate Zone"
(except seismic methods)

Utah Demonstration Summary

Location	Type of Test	Test Details	Estimated Capacity & Value Added Benefit
Aneth Field, Paradox basin, near Bluff, UT	**- Deep Saline** **- EOR with Sequestration**	**Up to 150,000 (?) tons/year for 3+ years** **MMV Focus:** **- Optimized seismic imaging** **- focus on maximizing resolution of the "Intermediate Zone"**	**- An estimate of minimum capacity of test unit: 100,000,000 tons** **- Value added Benefit: enhanced oil recovery** **- Expected increase in oil recovery: minimum additional 15,000 BOPD**



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