Can carbon capture and geologic storage mitigate greenhouse gases?

GCCC Digital Publication Series #10-03

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Keywords:
Overview

Cited as:
Trevino, R.H., Can carbon capture and geologic storage mitigate greenhouse gases?: presented at the Biennial Alberta-Texas Global Climate Forum, Austin, TX, April 7, 2010. GCCC Digital Publication Series #10-03.

Can Carbon Capture and Geologic Storage Mitigate Greenhouse Gases?

Gulf Coast Carbon Center, Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin

Presented at Biennial Alberta-Texas Global Climate Forum Austin, Texas April 7, 2010 *After Copenhagen: Collaborative Responses to Climate Change*

Bureau of Economic Geology - 100 Years of Scientific Impact

- First organized research unit of The University of Texas at Austin
- State Geological Survey of Texas
- One of three units of the Jackson School of Geosciences
- Staff—140, includes 80 researchers
  - Fossil energy
  - Environment
  - Outreach
- Advising state and federal government
  - Maintaining collections for research

1909-2009

Research Sponsors

SECARB team

Gulf Coast Carbon Center Sponsors

Southern States Energy Board
Ken Nemeth Dir, Jerry Hill PM
Bruce Brown NETL manager

Parallel projects GCCC involvement

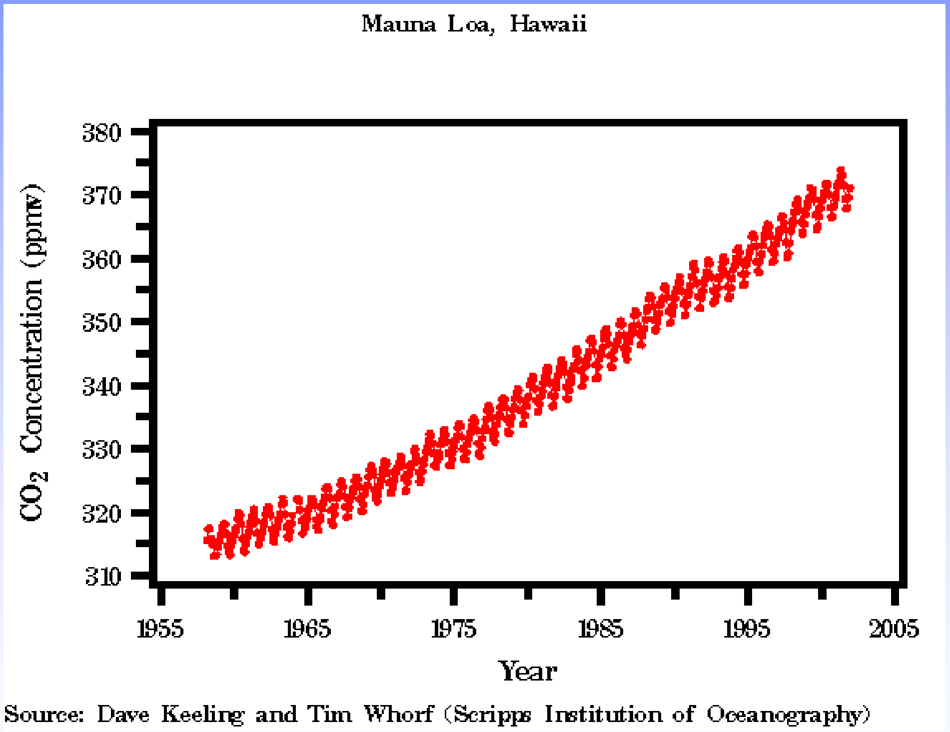
Other SECARB projects
SWP
BES - UT Center for Energy Frontiers
EPA projects
CCP
Texas Offshore Study - FOA 33
Industry sponsored projects - FOA 15

CO_2 Increasing in the Atmosphere

CO_2

- Produced by burning fossil fuels
- Atmospheric accumulation during industrial revolution
- Improving global living standards = increased atmospheric CO_2

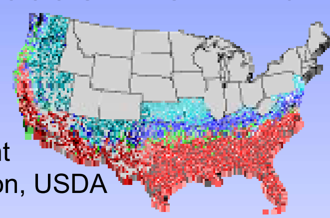
Recent increase in CO_2 concentration

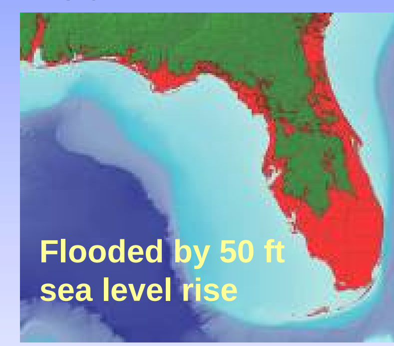


US Risks from Greenhouse Gas Emissions - Contribution to the Solution

- US is vulnerable to damage resulting from climate change
  - Hurricane landfall around Gulf of Mexico
  - Risk of tropical species invasion
  - Much of US low relief coastline – inundation by sea level rise

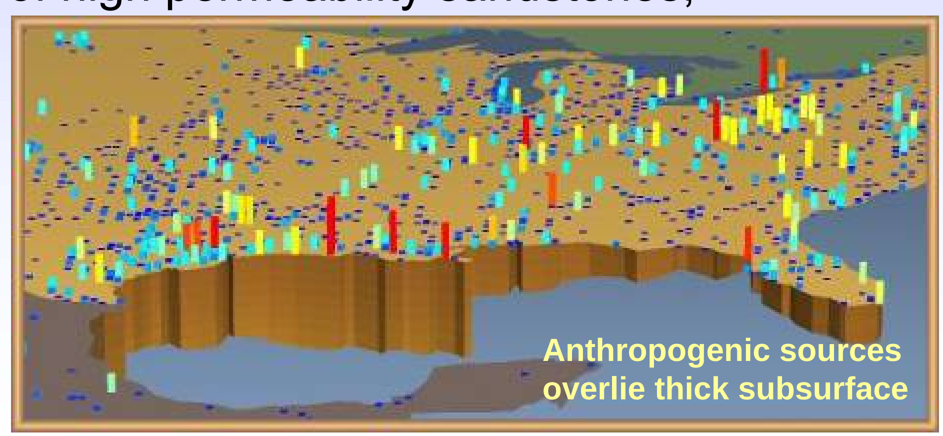
Fire ant
Invasion, USDA





High sequestration potential

- Energy industry center (refinery and oil production)
- Very well known, thick wedge of high permeability sandstones, excellent seals
- Initiated by CO_2 EOR



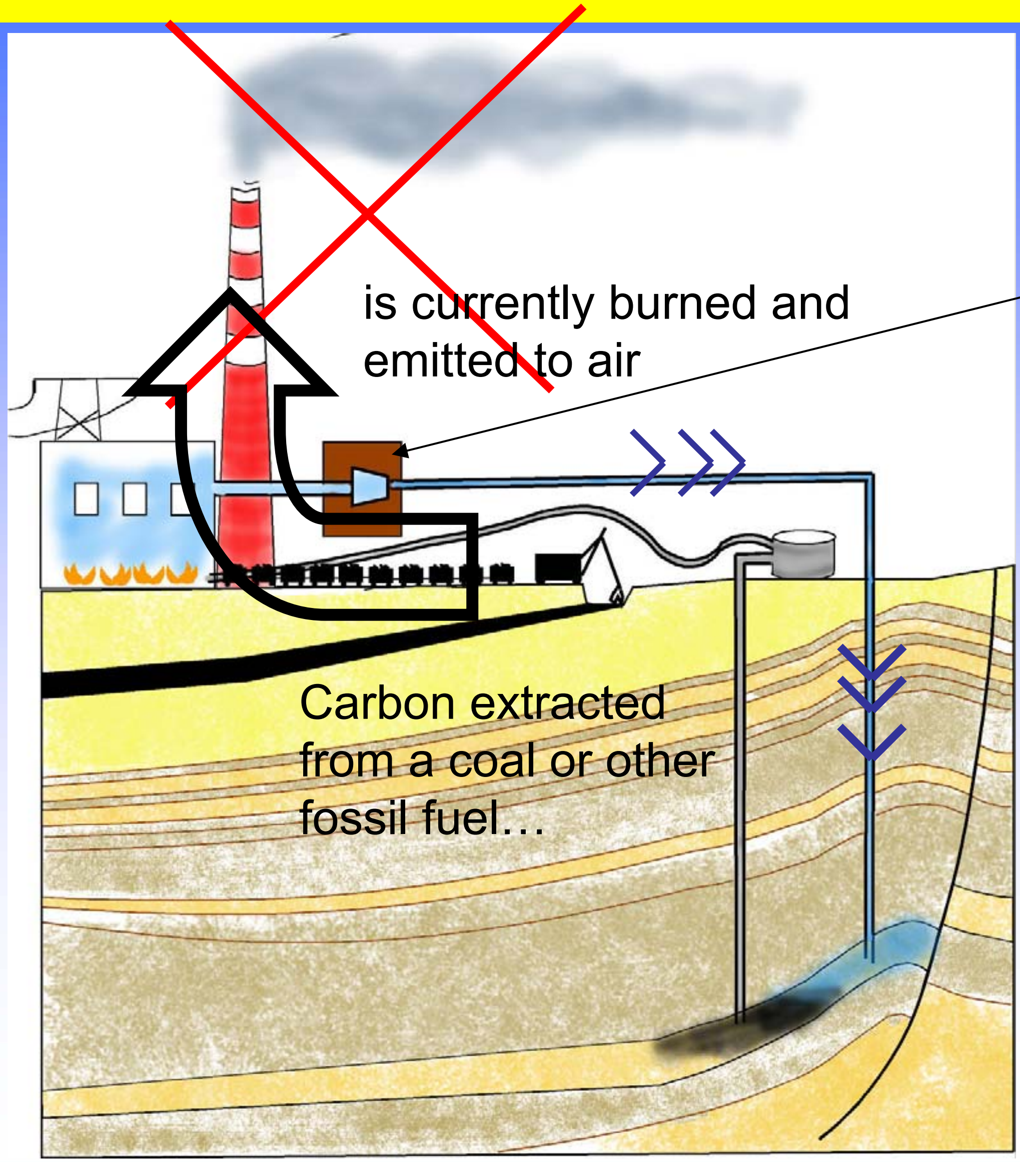
Options to Reduce CO_2 in the Atmosphere

- Conservation and energy efficiency
- Fuel switching—e.g., natural gas for coal
- Renewable energy—e.g., wind, solar, nuclear
- Terrestrial sequestration—e.g., rainforest preservation, tree farms, no-till farming.
- Ocean disposal
- **Geologic storage "sequestration"**
- "Novel concepts"

Which Is Best?

To reduce the large volumes of CO_2 that are now and will be in the future released to the atmosphere, multiple options must be brought to maturation.

What is Geologic Sequestration?



To reduce CO_2 emissions to air from point sources..

CO_2 is captured as concentrated high pressure fluid by one of several methods..

CO_2 is shipped as supercritical fluid via pipeline to a selected, permitted injection site

CO_2 injected at pressure into pore space at depths below and isolated (sequestered) from potable water.

CO_2 stored in pore space over geologically significant time frames.

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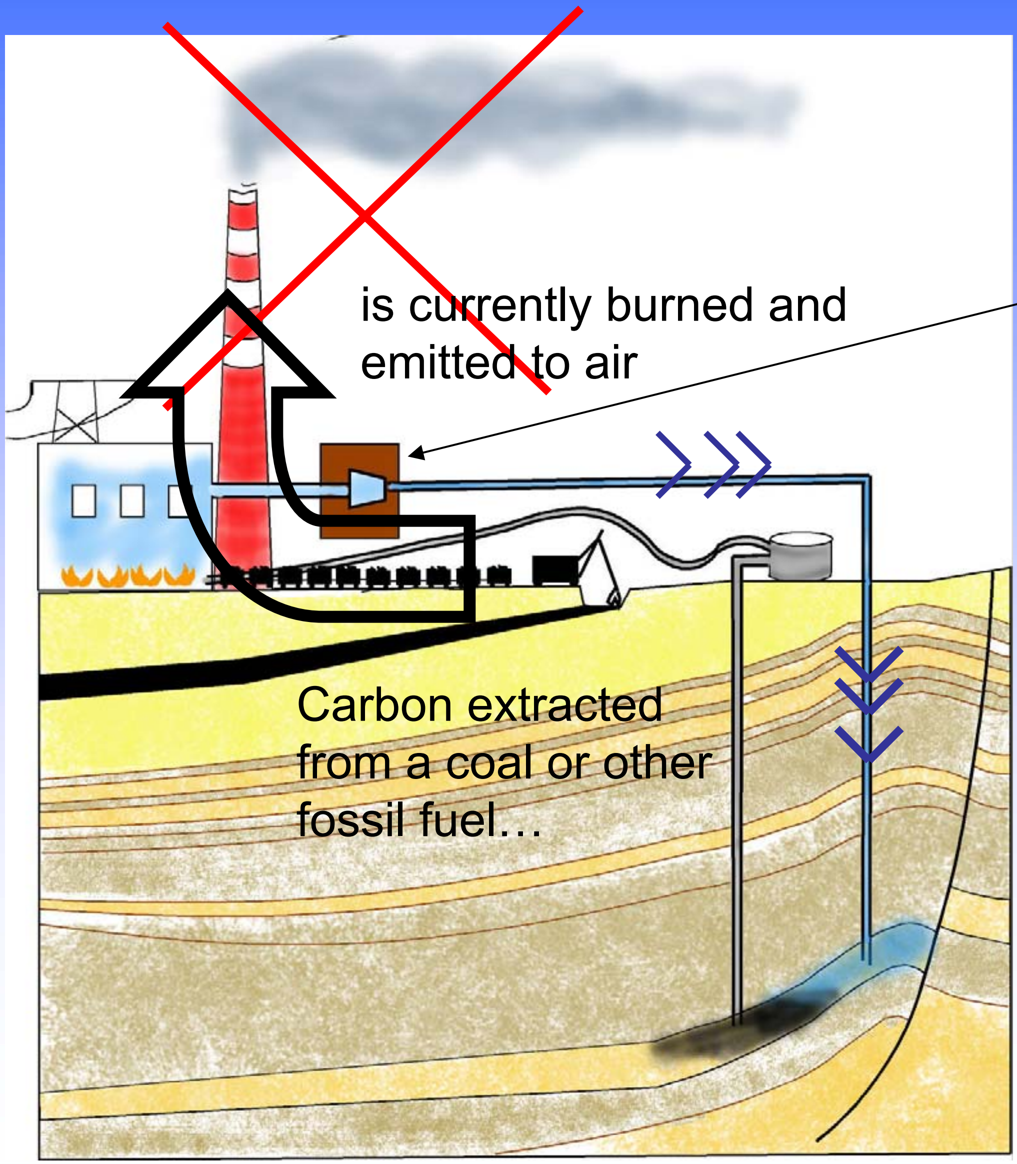
What is Geologic Sequestration?



To reduce CO_2 emissions to air from point sources..

Captured - concentrated high pressure fluid

Shipped - pipeline

Injected & isolated potable water

Stored (pore space) Geologically significant time

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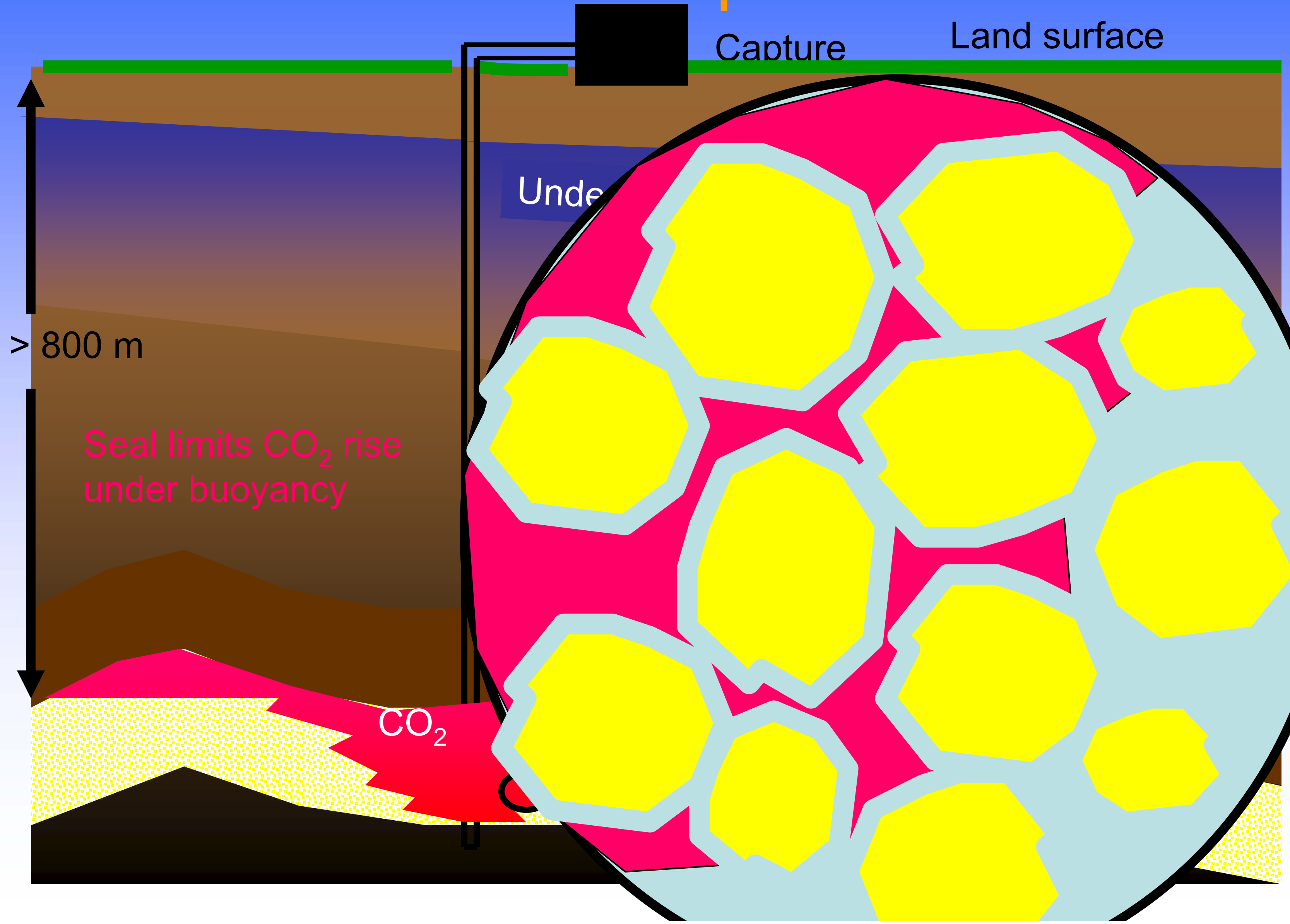
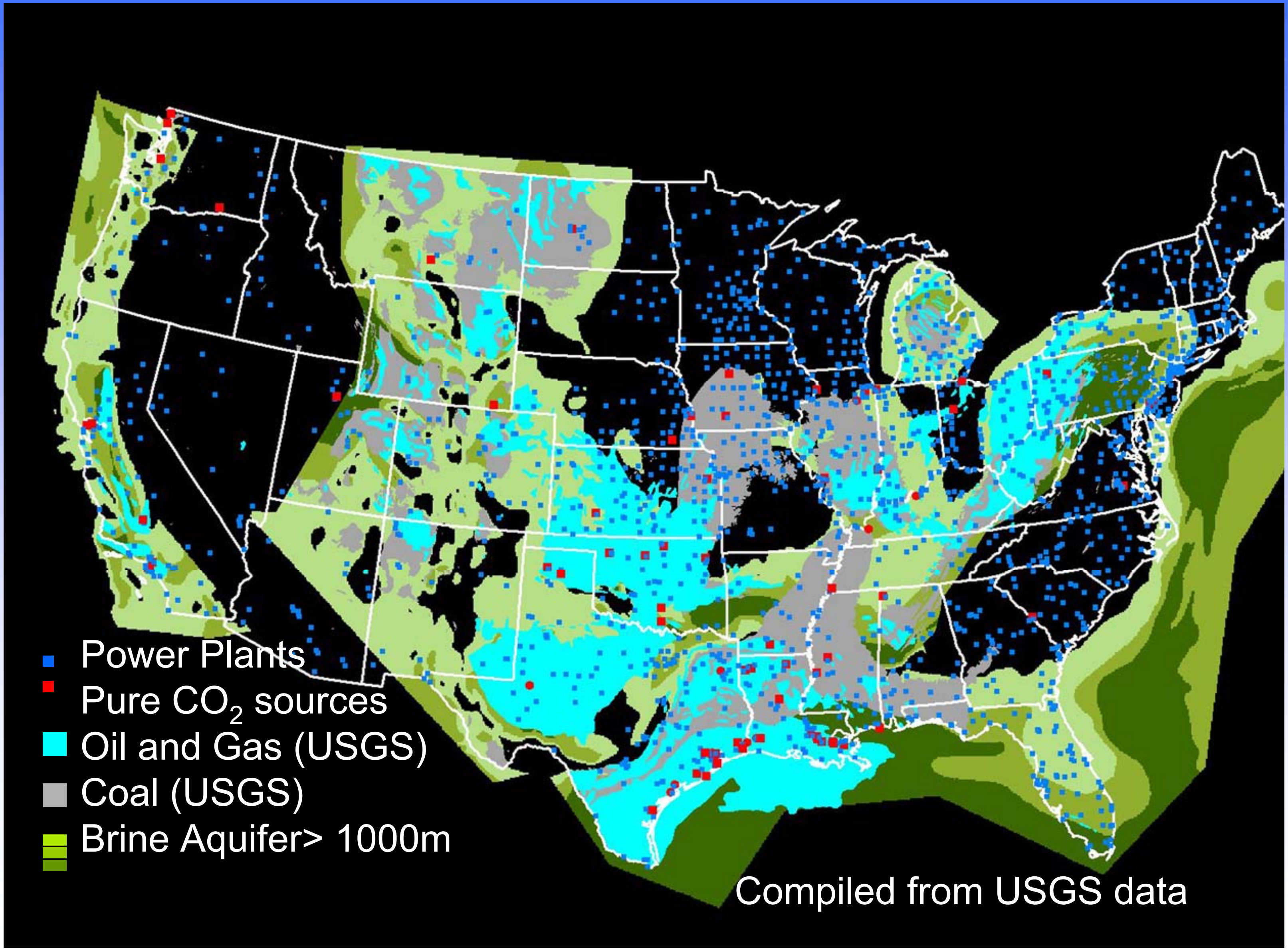
Geologic Sequestration - Ready?

- Subsurface volumes adequate?
- Storage security adequate?
- System mature enough?

Capacity = Volume of Assured Permanent Sequestration



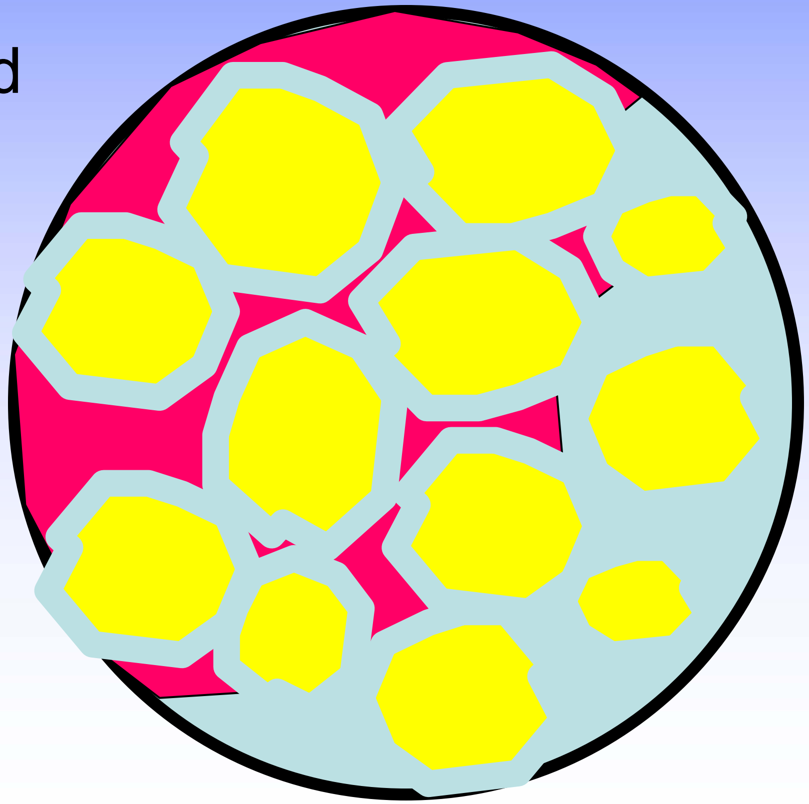
US CO_2 Sources and Sinks



Assessing Adequacy of Subsurface Storage Volumes

- CO_2 non-ideal gas: at depths >800 m dense phase 0.6g/cc and compressibility decreases
- Subsurface pore volume

  V= A x H x phi
- Efficiency of volume occupied
  - Residual water
  - Sweep efficiency
  - Pressure limits
  - Water displacement
- Economic and risk factors
  - Resources –water - & gas
  - Unacceptable risks
  - Other "no-go" areas
  - Cost



Adequacy of Storage Security - Perceived Risks

Speculation about risks from geologic sequestration of carbon dioxide (CO_2) has been dominated by concerns such as:

- Escape leading to asphyxiation
- Escape leading to toxicity of drinking water
- Induced earthquakes

Perceived risk: CO_2 escape leading to asphyxiation

"CO_2 releases are deadly for communities:"

"….If the gases leak out they are **deadly to all living creatures** since CO_2 is lighter than air, and displaces air. When the gases are released they stay close to the ground, displace oxygen, and **suffocate everything in its path**. Two events in the relative recent history of CO_2 emissions from natural sources underscore the community health hazard created if CO_2 were to escape from sequestration:

The largest recent disaster caused by a large CO_2 release from a lake occurred in 1986, in Cameroon, central Africa. A **volcanic crater-lake known as Nyos** belched bubbles of CO_2 into the still night air and the gas settled around the lake's shore, where it killed 1800 people and countless thousands of animals.

The 15 August 1984 gas release at Lake Monoun that killed 37 people (Sigurdsson and others, 1987) was attributed to a rapid overturn of lake water with CO_2 that had been at the bottom coming to the surface, triggered by an earthquake and landslide. The emission of around 1 cubic kilometer of CO2 devastated a local village and killed animals for miles.

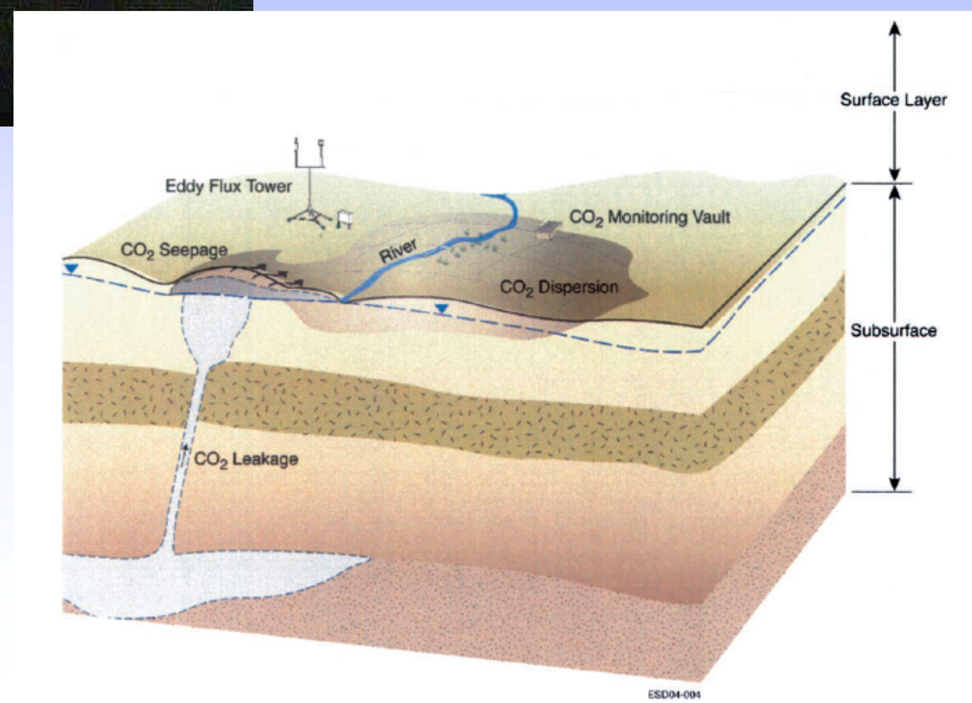
Carbon sequestration would most likely be in oil fields in California, many of California's oil fields are in our largest, most populous cities. As well, California has **oil fields in poor, rural communities**. Carbon sequestration in both of these cases will have a huge effect on environmental justice communities."

Environmental Justice objection to CA AB 705
Letter* to Assembly member Hancock, April, 2008
(emphasis mine)

Risk Myth Explained: escape leading to asphyxiation

- CO_2 is a well known confined space risk – CO_2 is 1/3 denser than air (N_2 and O_2) therefore will effectively displace air from a tank, mine, cave, or crater.
- Air and CO_2 are miscible with no viscosity contrast, so CO_2 rapidly disperses in an open setting, on a slope, with breeze or circulation.

Cool CO_2 pooling on the ground in the still night air but at low concentrations Frio brine pilot, Houston, TX –
No Danger



Topography or wind will cause CO_2 to spread and mix
Oldenburg and Unger, 2004, Vadose Zone Journal 3:848-857
No danger

Crystal Geyser, Utah

Other CO2 geysers through wells:
Source Intermittente de Vesse, France,
Boiling Fount, Germany,
Herlany Geyser, Slovakia,
Natural setting – Salton Sea, California

- Natural CO_2 drives fresh water through a1930's well that was improperly plugged – forms an off-road tourist destination and swimming hole. Open setting- no asphyxiation risk.

Perceived Risk: escape leading to toxicity of drinking water

- "Carbon Sequestration….
  - Will require transformation of CO_2 gas to CO_2 liquid which is acidic
  - CO_2 liquid's acid nature is corrosive to the underground environment, contaminating the ground and would eventually leach to the surface.
  - When CO_2 leaches up to the surface, it will contaminate underground fresh drinking water aquifers, lakes, rivers, and the ocean"

Excerpts from "Carbon Sequestration Public Health and Environmental Dangers"
Researched by Coalition For a Safe Environment

Risk Myth Explained: CO_2 dissolved in aquifers could damage water quality

CO_2 dissolves in water = dissolution trapping

$CO_2(g) + H_2O \leftrightarrow H_2CO_3(aq)$
$H_2CO_3(aq) \leftrightarrow HCO_3(aq)^- + H^+$
$HCO_3(aq)^- \leftrightarrow CO_3(aq)^{--} + H^+(aq)$

Acid= tang in carbonated water

Acid is buffered by rocks

increase Ca, Mg, Fe, Na, Si, CO_3, SO_4, etc. in solution

What could the etc. be?

Mn, As, Pb, Sr, Ni, Zn, Ag, U, Ni, Cd……

So would leaked CO_2 be a risk to drinking water?

Carbonated water…

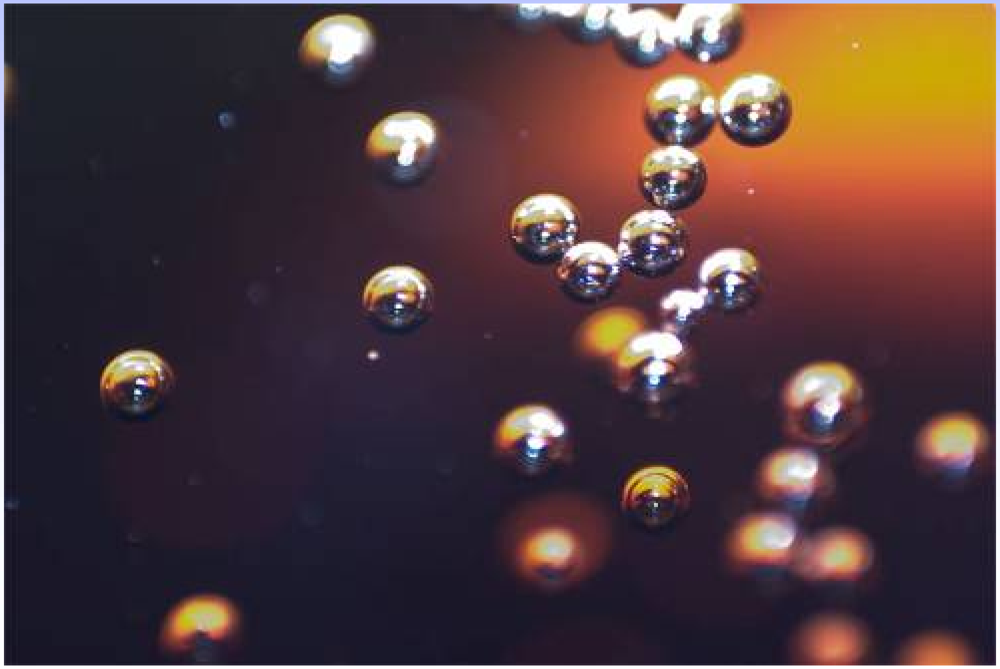
Otherwise known as sparkling water. Has variable mineral content but is potable

Increasing concern in sequestration community about "metals"

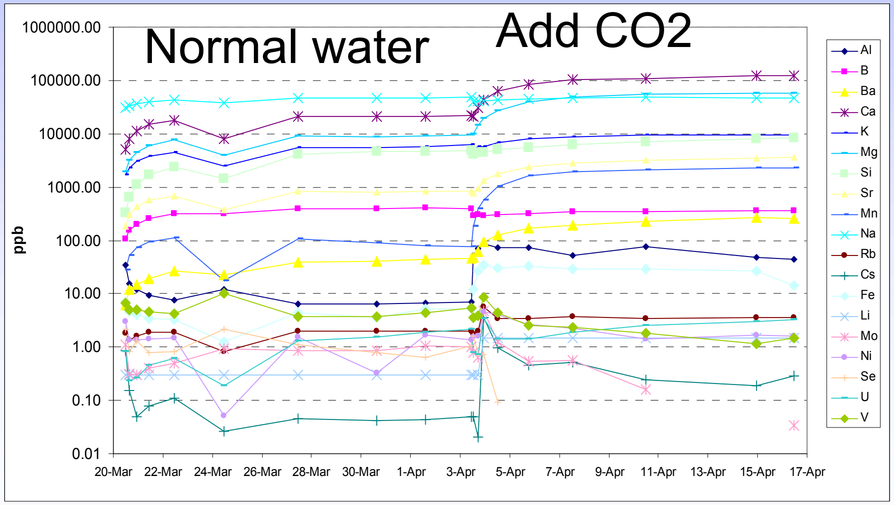
EPA geologic sequestration draft rule

John Apps et al. EPA contract report

Press coverage of Kharaka Frio results



Laboratory Experiments-Adding CO_2 to aquifer rock-water system



- Add CO_2 to typical aquifer rocks + fresh water – increase in dissolved minerals – proportional to constituents already in water.
- Unless aquifer is already marginal, CO_2 –rock-water reaction poses little risk

GCCC staff Corrine Wong, Jud Partin
Jiemin Lu, Changbing Yang

Perceived Risk: Injection causing earthquakes

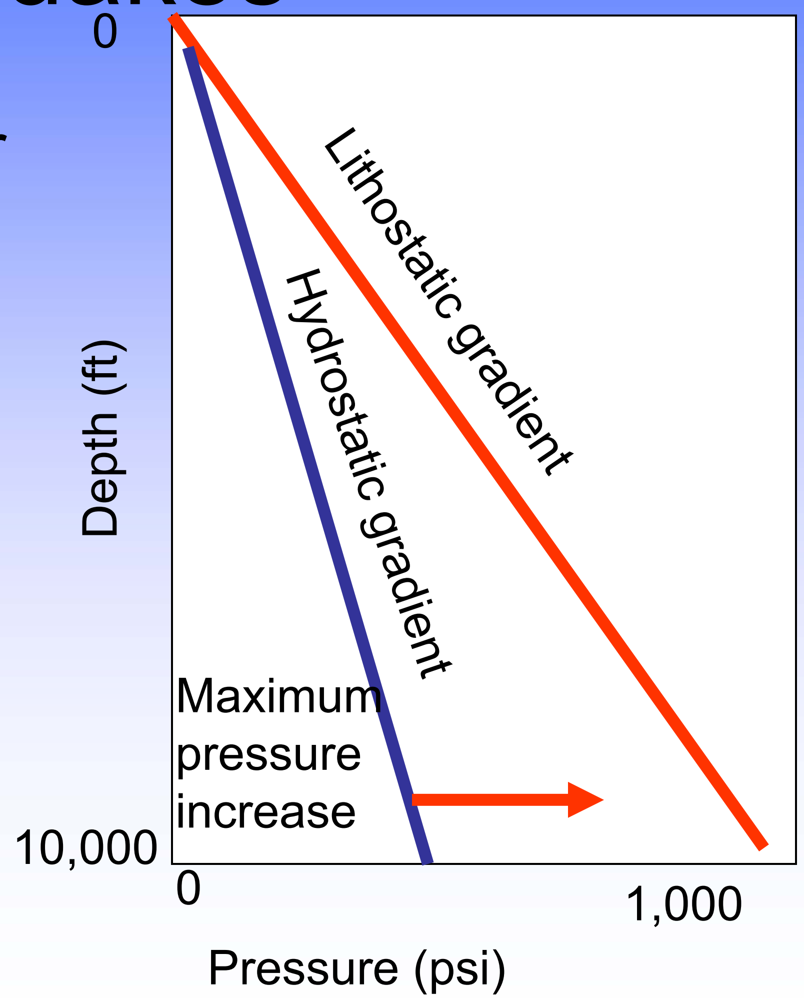
- In the first *Superman* movie, supervillain Lex Luthor plans to trigger a massive, California-detaching earthquake by detonating a couple of nuclear weapons in the San Andreas Fault.
- Crazy Lex! That scheme never would have worked, geologists will tell you. But, if he'd been serious about **creating an earthquake**, there are ways he could have actually done it. He would just have to **inject some liquid (as some carbon-sequestration schemes propose)** deep into the Earth's crust, or bore a few hundred thousand tons of coal out of a mountain.
- "In the past, people never thought that human activity could have such a big impact, but it can," said Christian Klose, a geohazards researcher at Columbia's Lamont-Doherty Earth Observatory.
- It turns out, actually, that the human production of earthquakes is hardly supervillain-worthy. It's downright commonplace: Klose estimates that 25 percent of Britain's recorded seismic events were caused by people.
- Most of these human-caused quakes are tiny, registering less than four on geologist's seismic scales. These window-rattlers don't occur along natural faults, and wouldn't have happened without human activity -- like mining tons of coal or potash. They occur when a mine's roof collapses, for example, as in the Crandall Canyon collapse in Utah that killed a half-dozen miners last year.

http://blog.wired.com/wiredscience/2008/06/top-5-ways-that.html

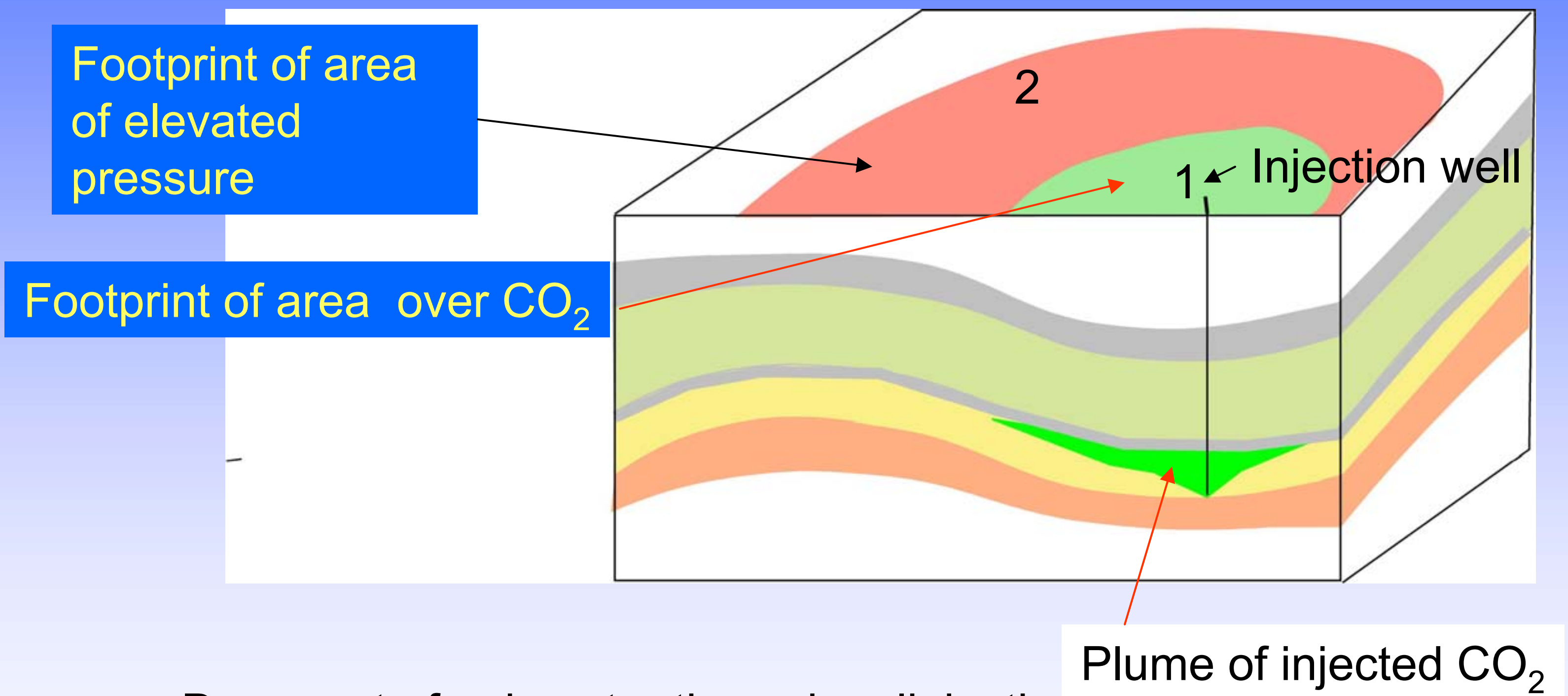
Emphasis added by me

Risk Myth Explained: Limiting injection pressure to avoid earthquakes

- Injection is used to cause "frac jobs" – microseismic events for reservoir stimulation. The pressure requirements are calculated, testable, and well documented.
- MASIP = Maximum Allowable Surface Injection Pressure is a main regulation of current EPA underground injection control program.
- Risk of accidental earthquake can be avoided by regulations in place.



Substantive Risk - Damage to Fresh Water resulting from brine (salt water) leakage

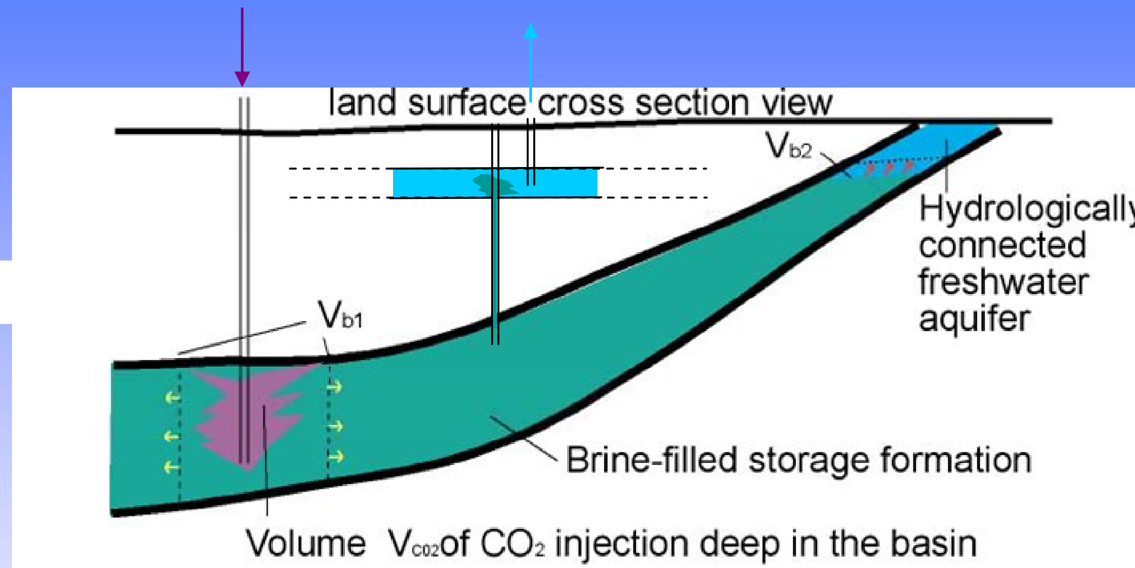


Damage to fresh water through salinization by water expelled during injection.

Managed in Underground Injection Control by assuring that well are plugged in area of review

Substantive Risks

Current GCCC work on Prediction of AoR and far field pressure



- Damage to surface freshwater (lakes) by increased acidity should CO_2 leak – e.g. fish kills when volcanogenic CO_2 leaked at Mammoth Lakes, CA.

Conclusion

- Geotechnical and environmental risks from sequestration are modest and well known
- Policy, regulatory, and legal frameworks can guard against risky geotechnical activities by requiring proper characterization and preventative measures.