

# Unexpected Difficulties with Geologic CO<sub>2</sub> Storage

Michael Economides/University of Houston

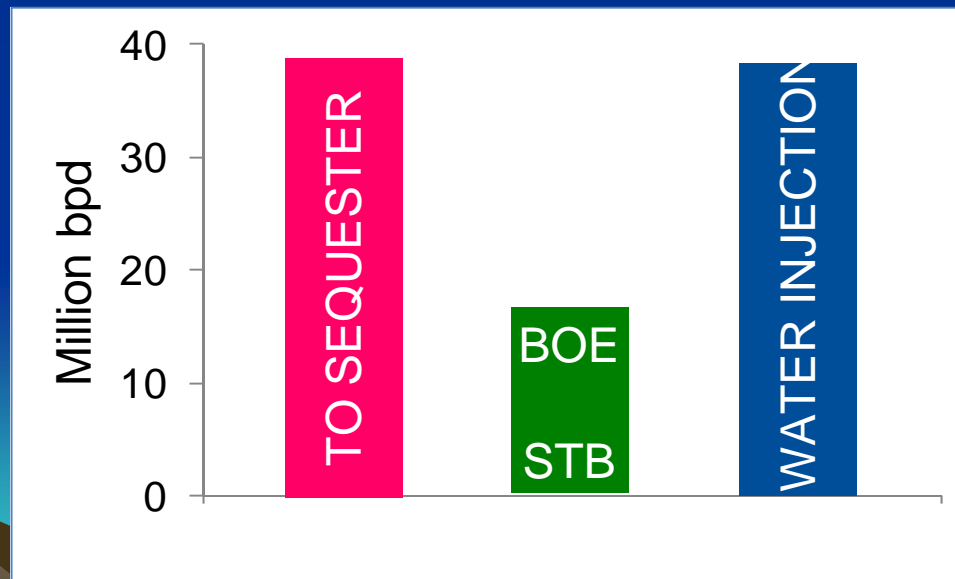
C.A. Ehlig-Economides/Texas A&M University



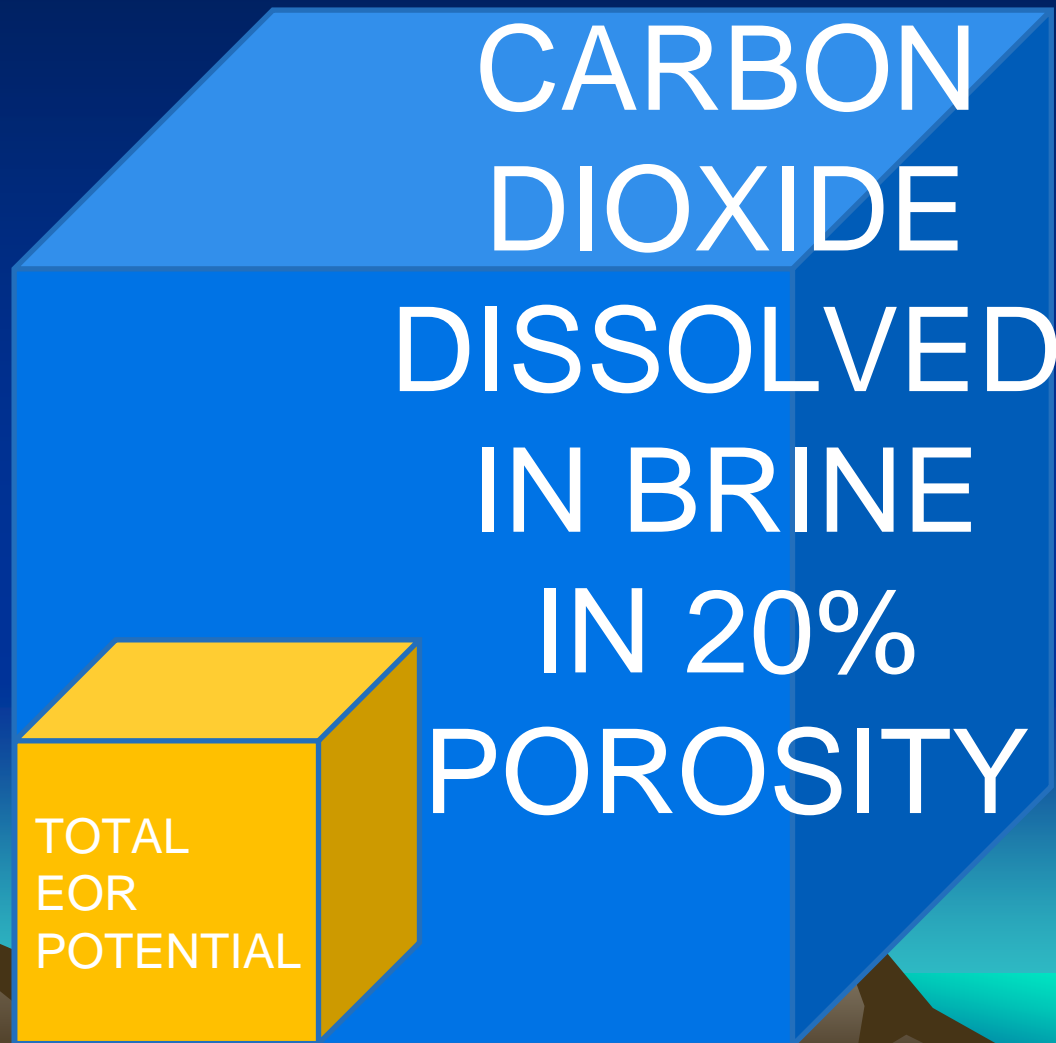
# The Rates (for the US)

1.75 billion tonnes annual reduction of CO<sub>2</sub> emissions by 2030

At 47.6 lb<sub>m</sub>/ft<sup>3</sup>, this is 39 million bpd to sequester

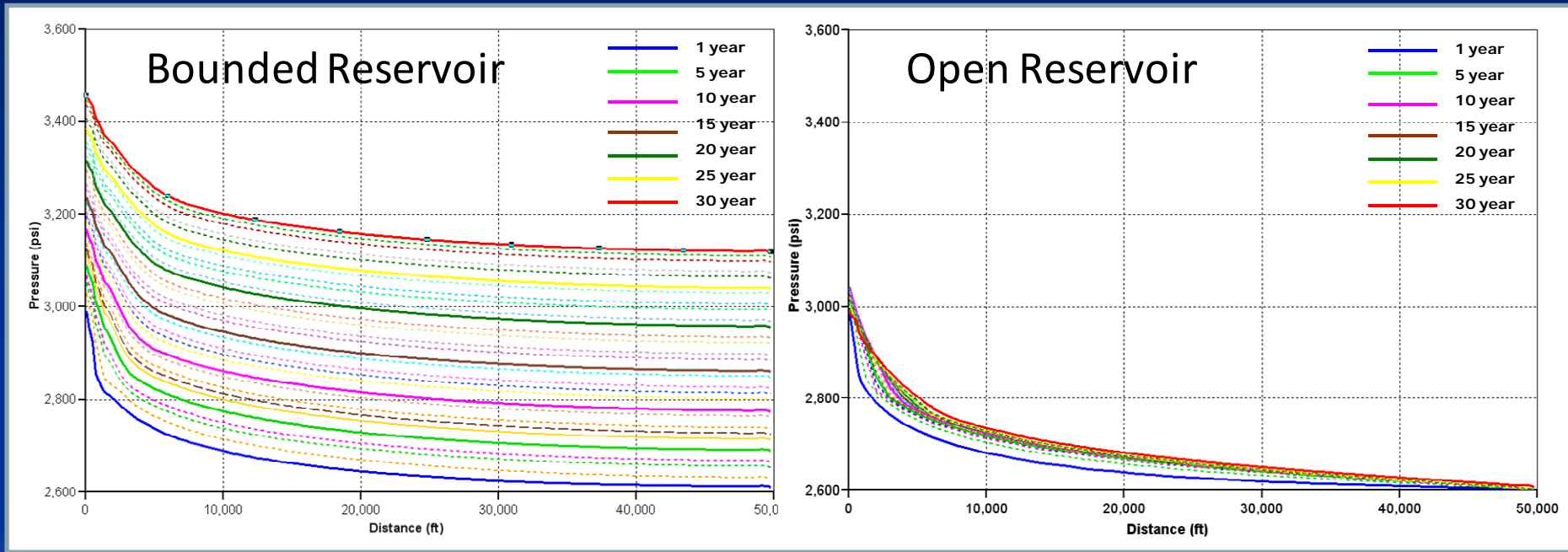


# The Volumes (Annual for US)





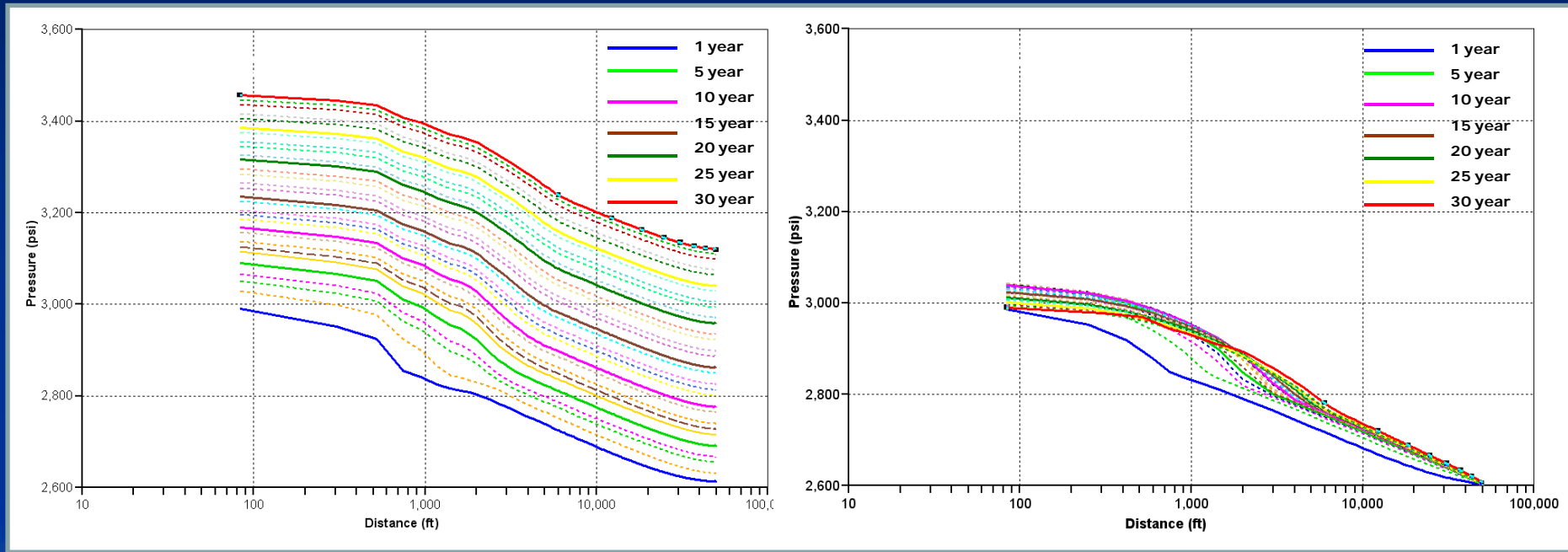
# Open Versus Bounded Pressure Behavior



Cartesian Scale



# Open Versus Bounded Pressure Behavior



Logarithmic Scale



# The Math

$$\Delta p_{max} = \frac{0.0690 V_{CO2}}{N_w k h t_{plant}} \left[ \frac{\mu_g}{k_{r,Sg=1}} \ln \left( \frac{r_{dry}}{r_w} \right) + \left( \frac{k_{rg}}{\mu_g} + \frac{k_{rw}}{\mu_w} \right)^{-1} \Bigg|_{S_{g,avg}} \ln \left( \frac{r_{BL}}{r_{dry}} \right) + \mu_w \ln \left( \frac{0.472 r_e}{r_{BL}} \right) \right] + \frac{V_{CO2}}{V_r c_t}$$

Reciprocal Radial Mobility, 1/M<sub>r</sub>

Dry Zone

Two-phase Zone

Brine Zone

Injection Term

Compression Term

$\Delta p_{max} = p_f - p_{hyd}$ , psi

$$\frac{\Delta p_{max}}{V_{CO2}} = \frac{0.0690}{M_r N_w k h t_{plant}} + \frac{1}{V_r c_t}$$

Total volume to inject, bbls

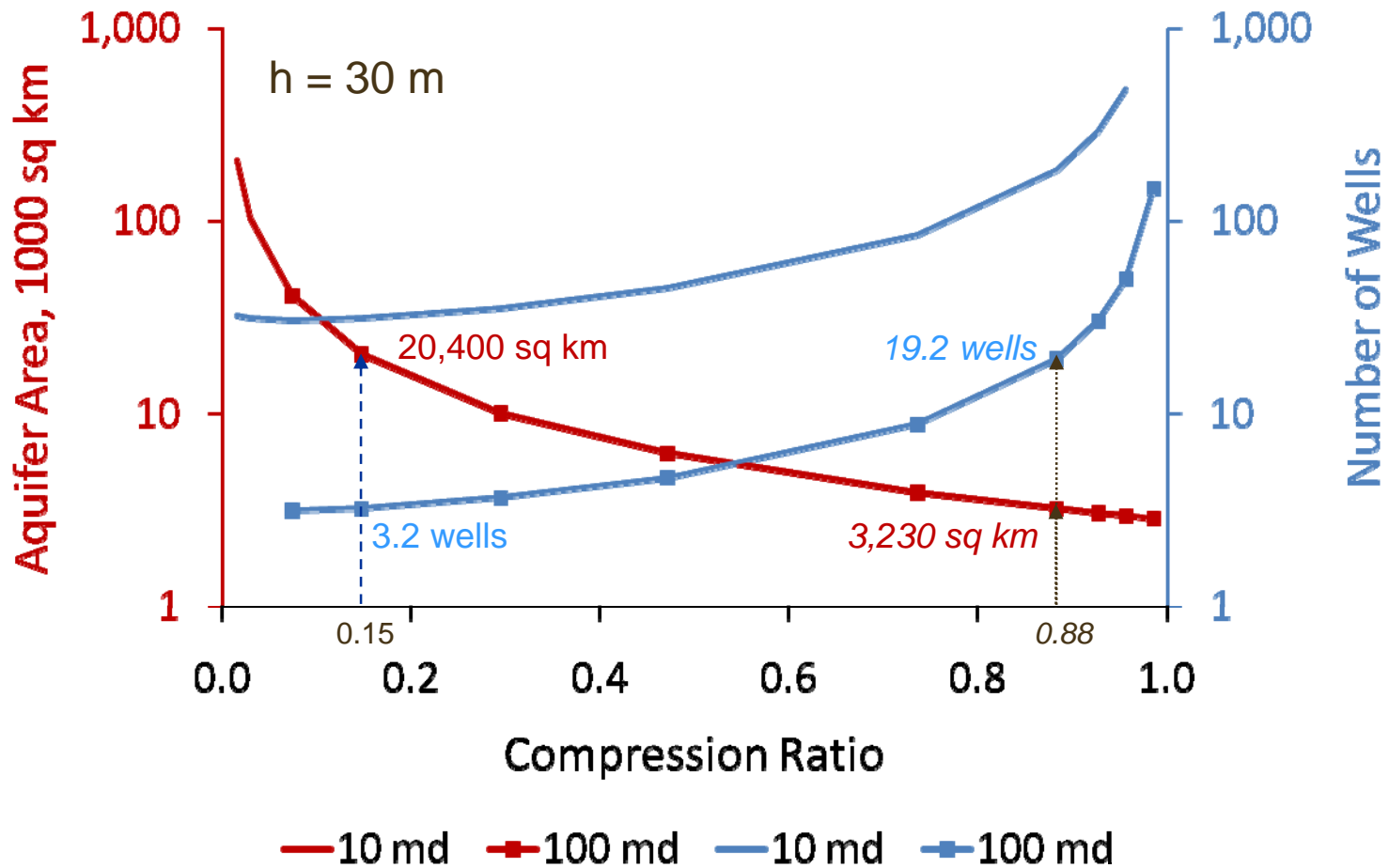
Radial Mobility

Number of injection wells

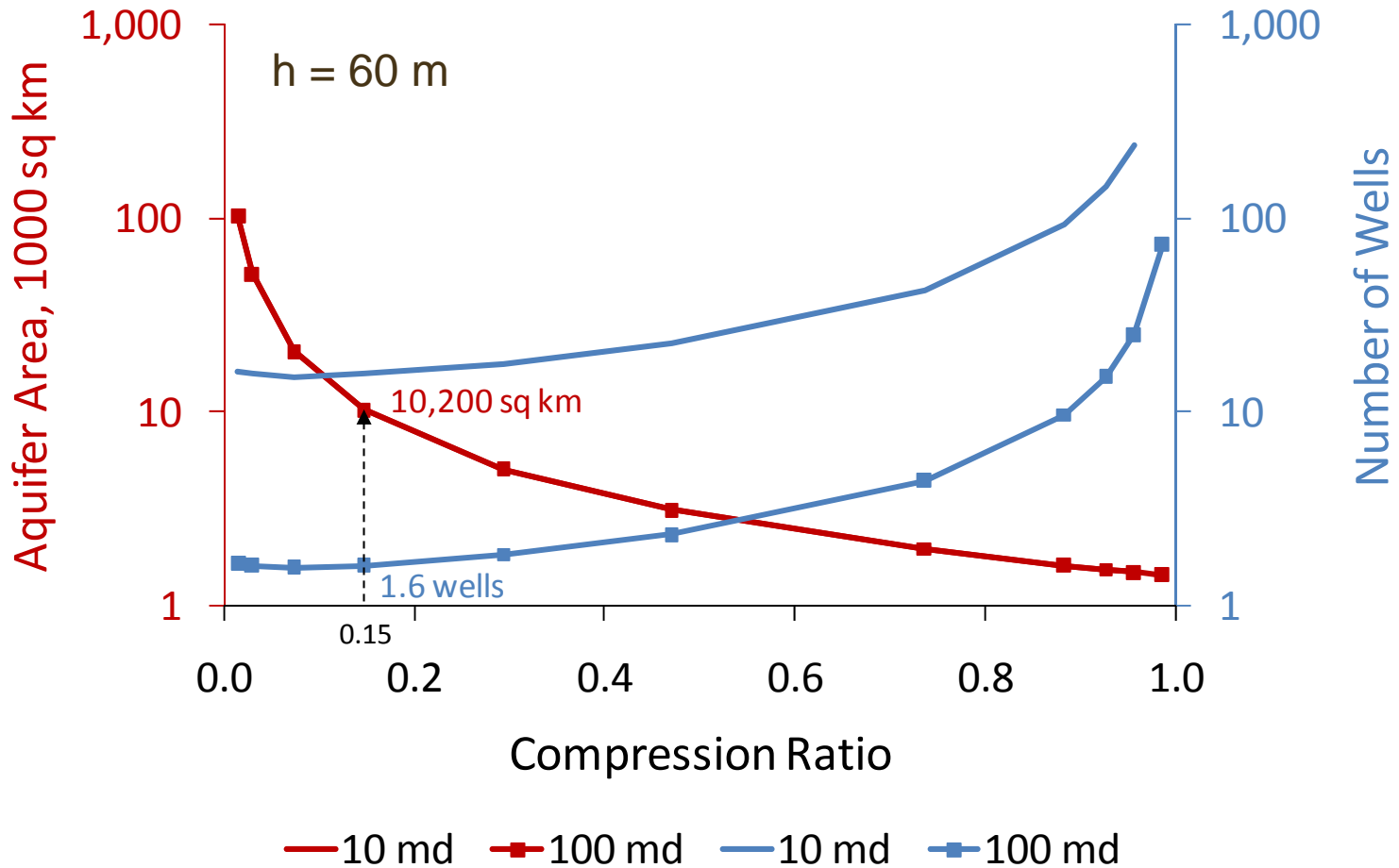
Plant lifetime, yrs

Aquifer volume, ft<sup>3</sup>

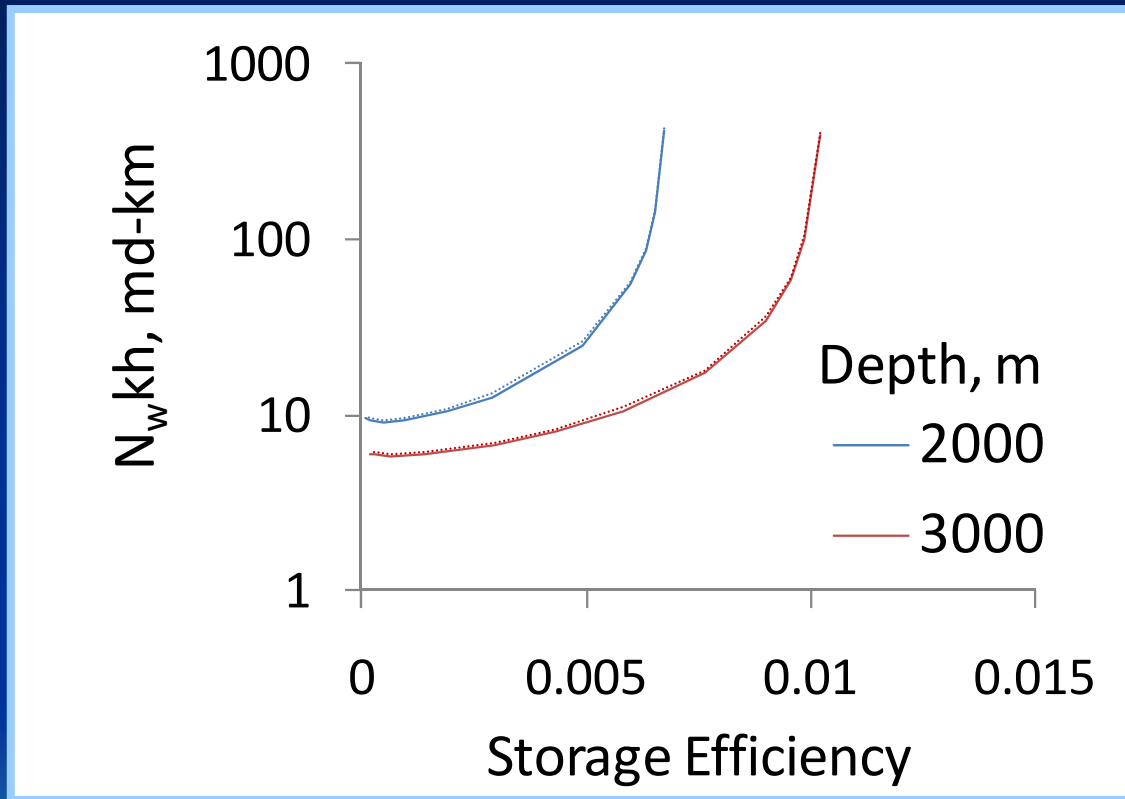
# Pressure, Area, Wells



# Pressure, Area, Wells



# Storage Efficiency



# Conclusions

- Supercritical CO<sub>2</sub> injection rate from a 500 MW coal power plant is ~70,000 bpd, depending on reservoir depth
- Focus here is on sequestration in deep saline aquifer **during** injection
- Analytical and numerical models agree
- Under bulk injection CO<sub>2</sub> occupies ~ 1% of **pore** volume, not **bulk** volume
- An aquifer with the areal extent of the Prudhoe Bay reservoir could require hundreds of wells to store CO<sub>2</sub> from a moderate size power plant, and even then only by pressurizing the aquifer



# Conclusions

- EOR injection rates under steady-state conditions are not analogs to bulk CO<sub>2</sub> injection in an aquifer
- EOR does not provide sufficient volume for CO<sub>2</sub> sequestration at power plant scale
- Bulk CO<sub>2</sub> injection is not a solution to CO<sub>2</sub> emission management
- Models showing CO<sub>2</sub> dissolution, residual trapping, and mineralization have deflected attention from the very real issues about simply how to actually get CO<sub>2</sub> into the ground in the first place

