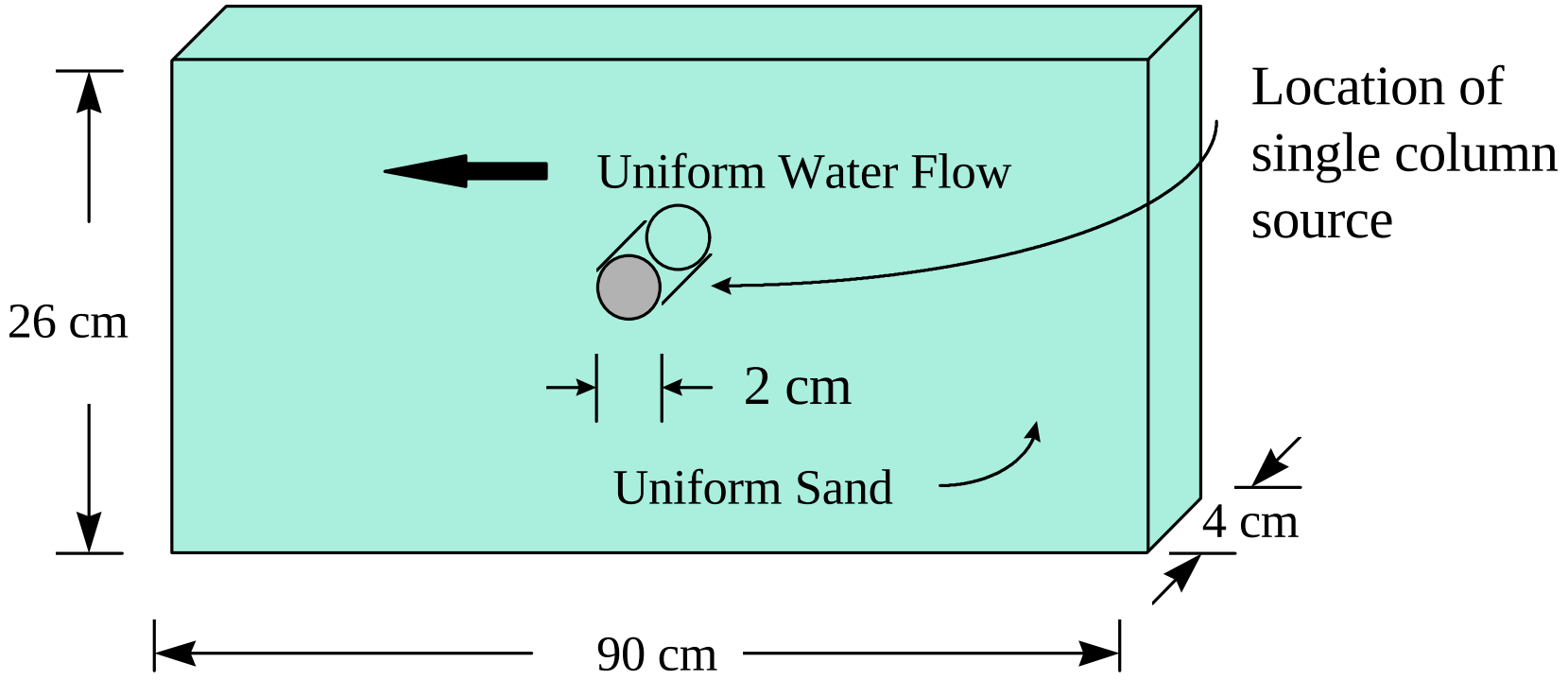
Headquarters U.S. Air Force

Integrity - Service - Excellence

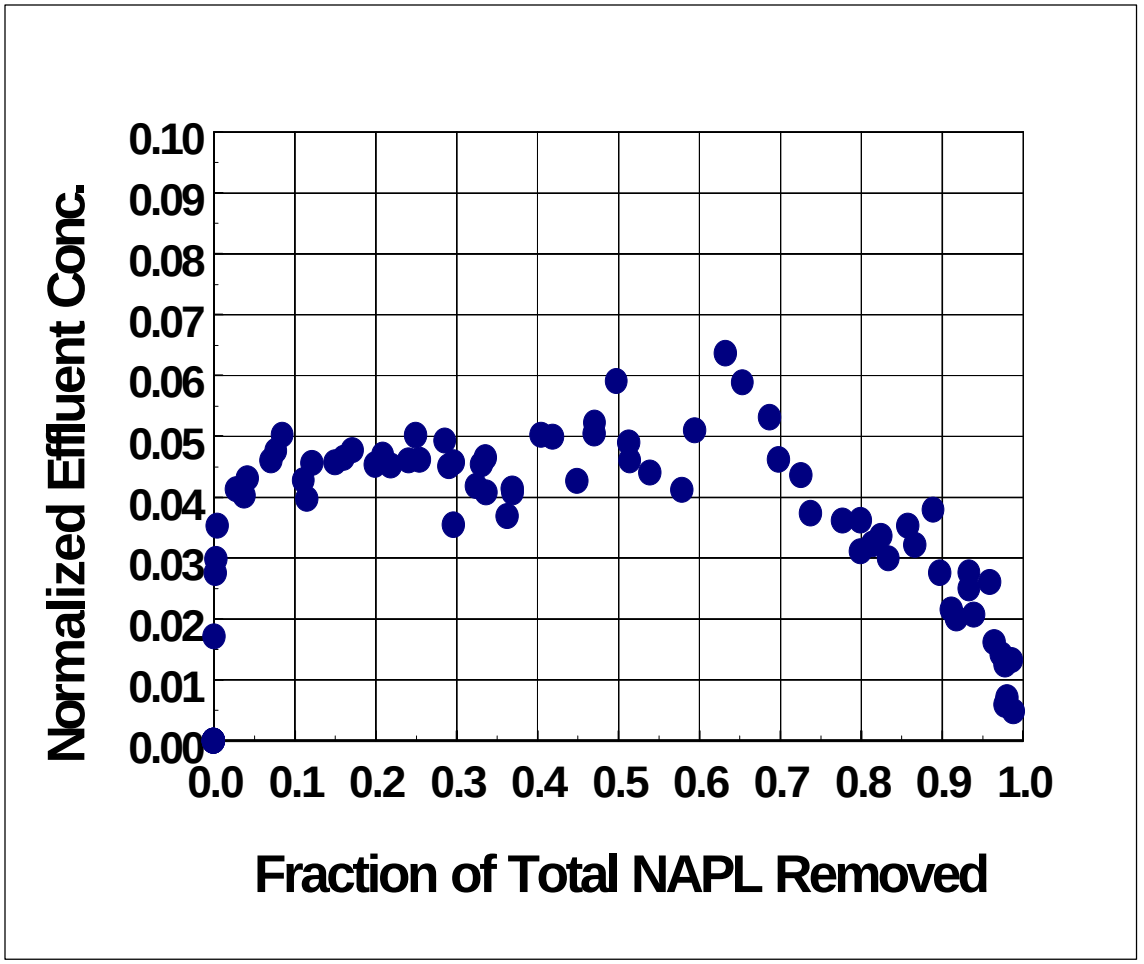
NAPL Source Zone Model

Tom Sale and Dave McWhorter

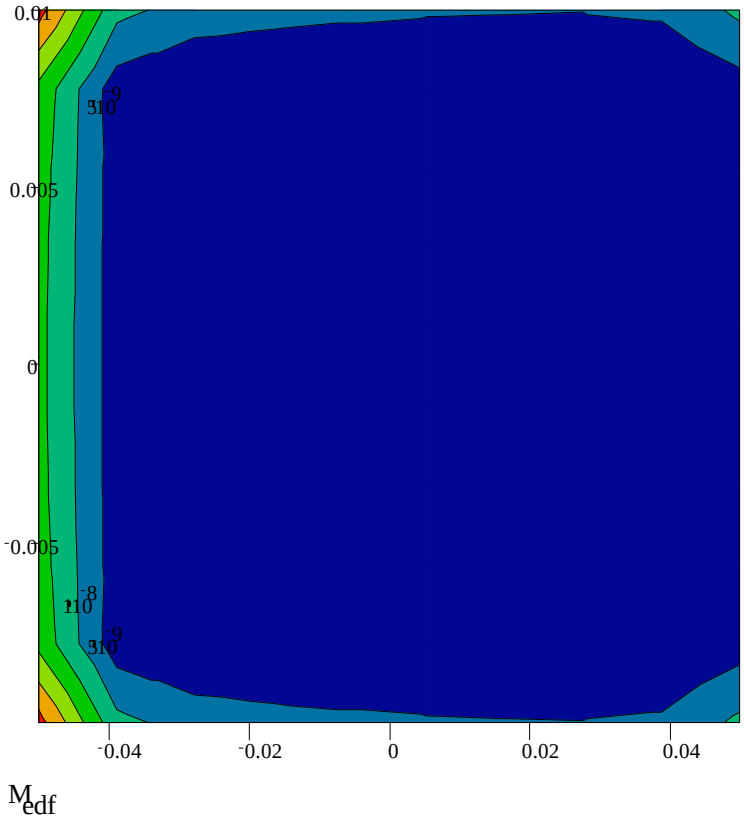
Column Source Laboratory Studies



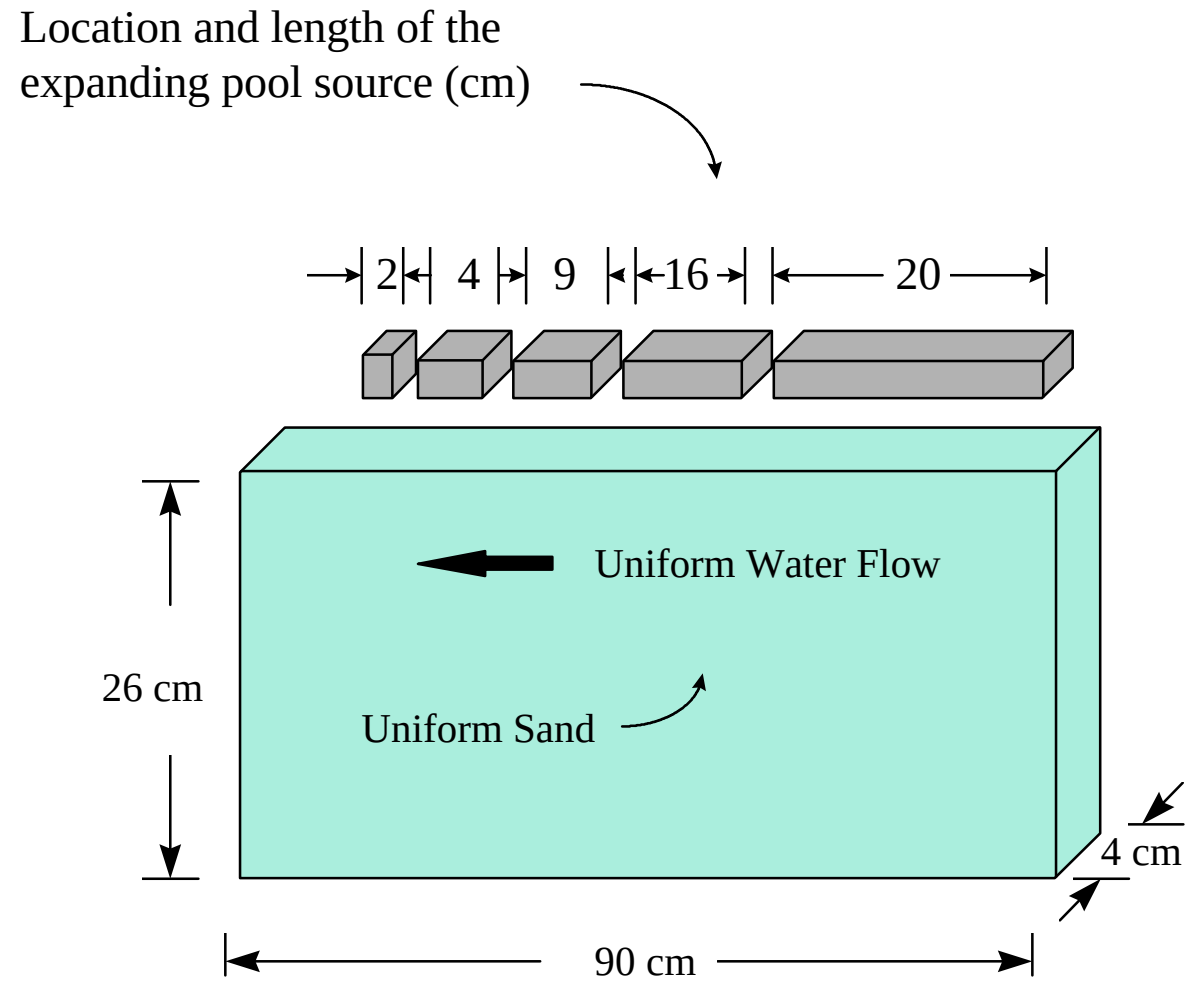
Column Source Results



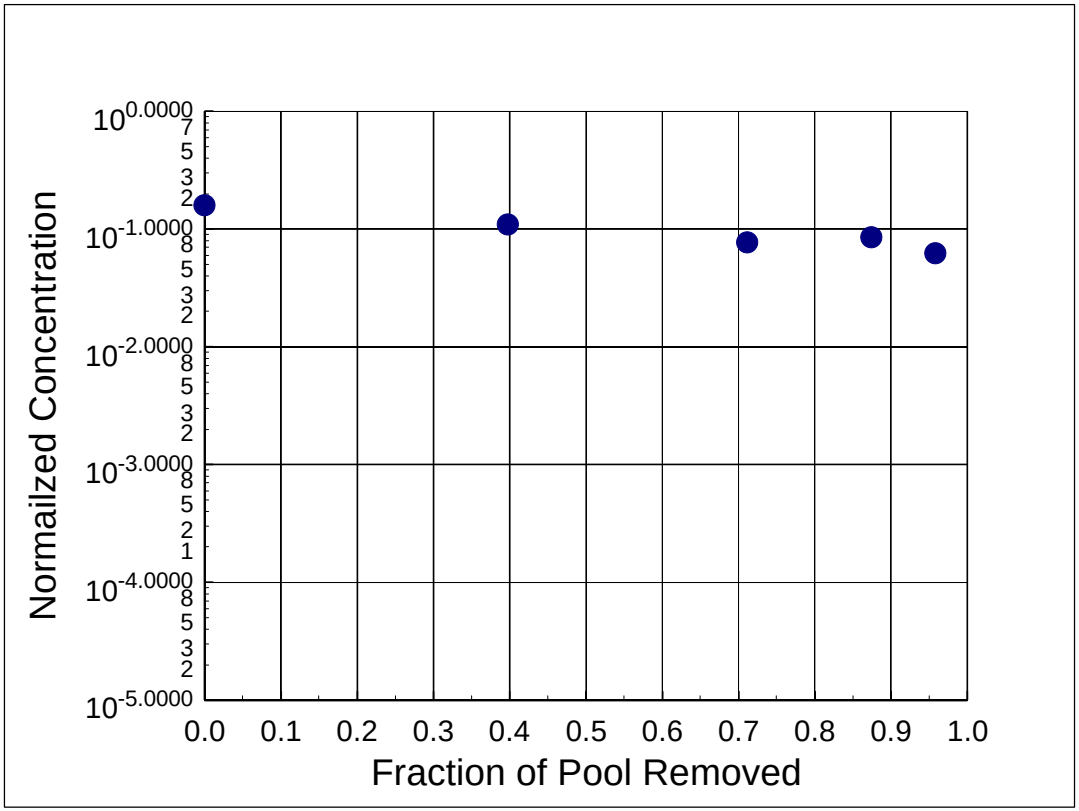
Distribution of mass transfer rates in a NAPL subzone



Expanding Pool Laboratory Studies



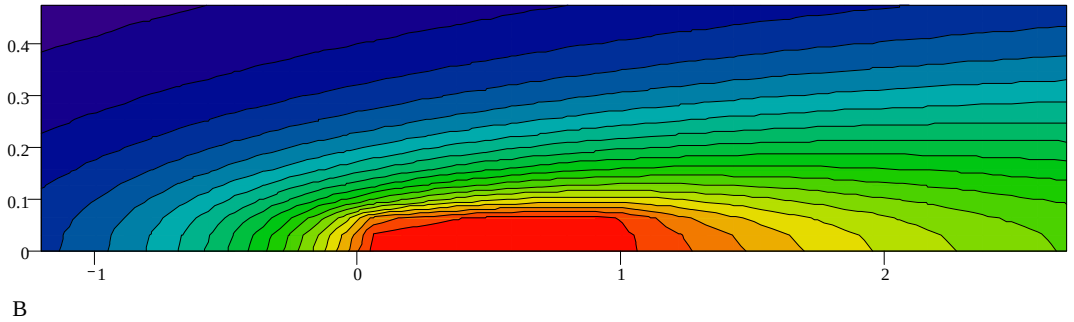
Expanding Pool Results



What Controls the Rates of Dissolution ?

Concentrations about the subzone are controlled by advection, longitudinal dispersion, and transverse dispersion

$$F = \frac{1}{f}\int_0^{\infty} f_x(x,a,t)\, f_y(y,b,t)\, f_z(z,c,t)dt$$

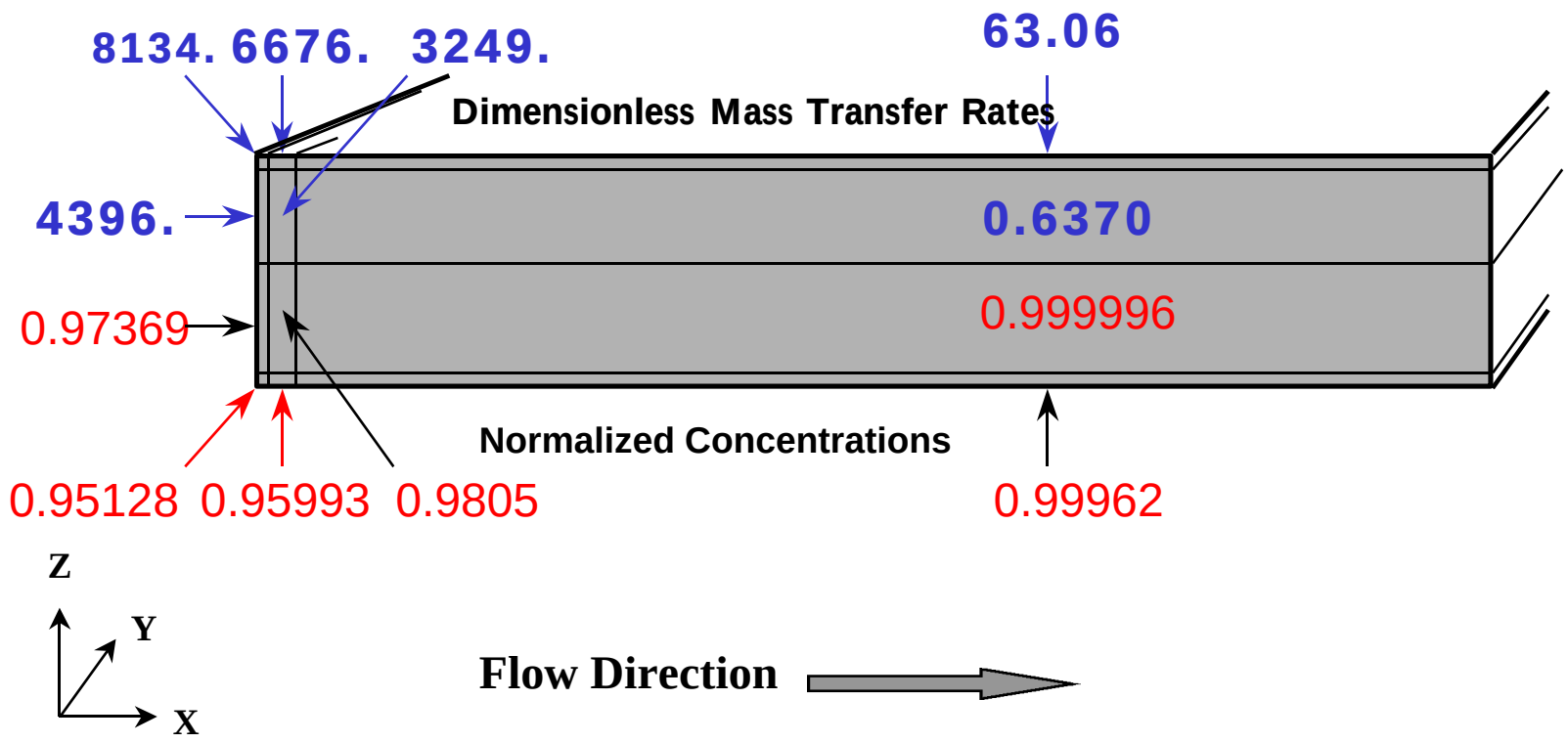


Concentrations within the subzone are controlled by rates of interphase mass transfer (primarily a function of NAPL saturation)

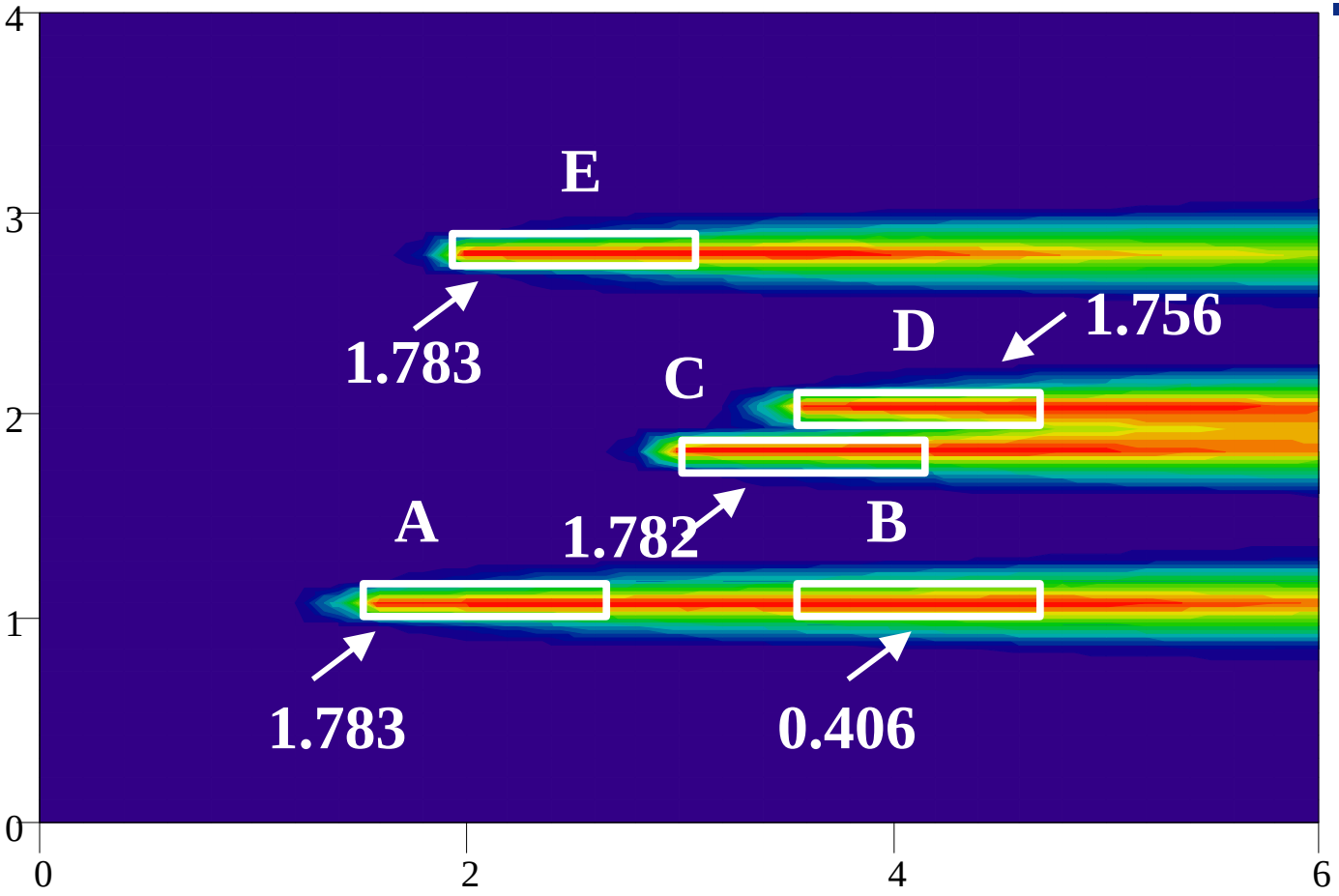
$$\dot{M}_v = K_l(C_s - C_a)$$

U.S. AIR FORCE

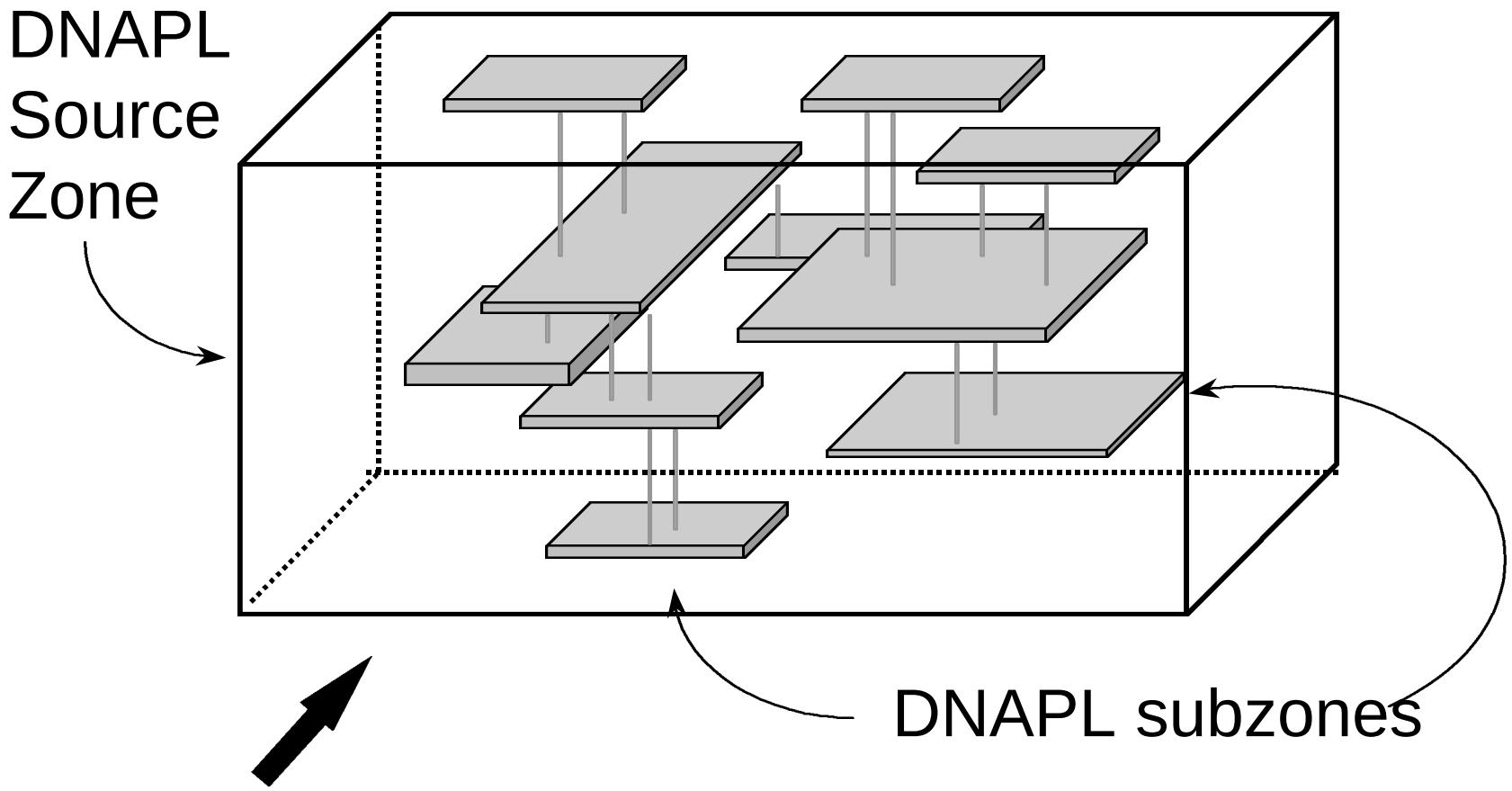
Dimensionless mass transfer rates and normalized concentrations within a DNAPL subzone



Multiple Pool DNAPL Source Zone

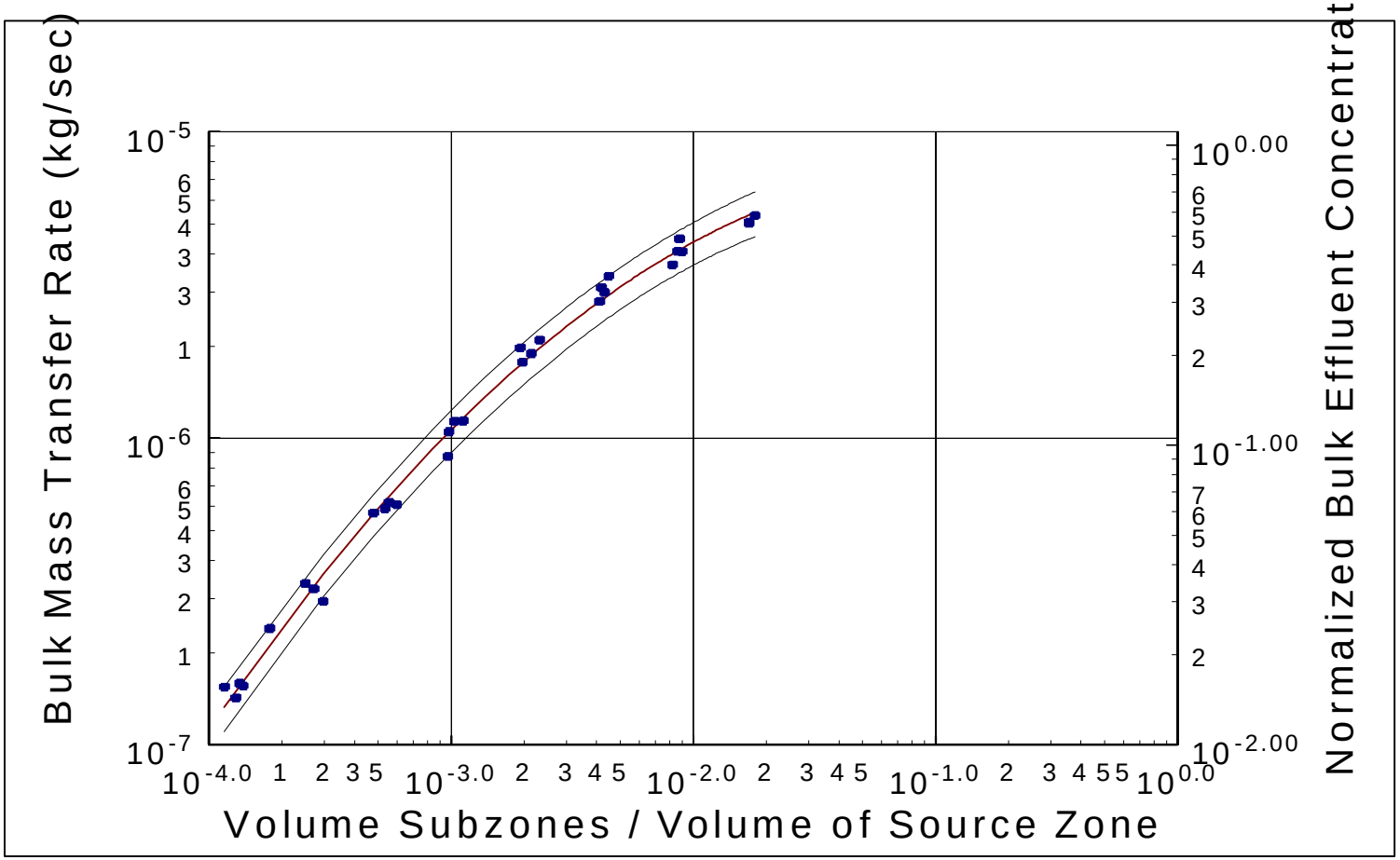


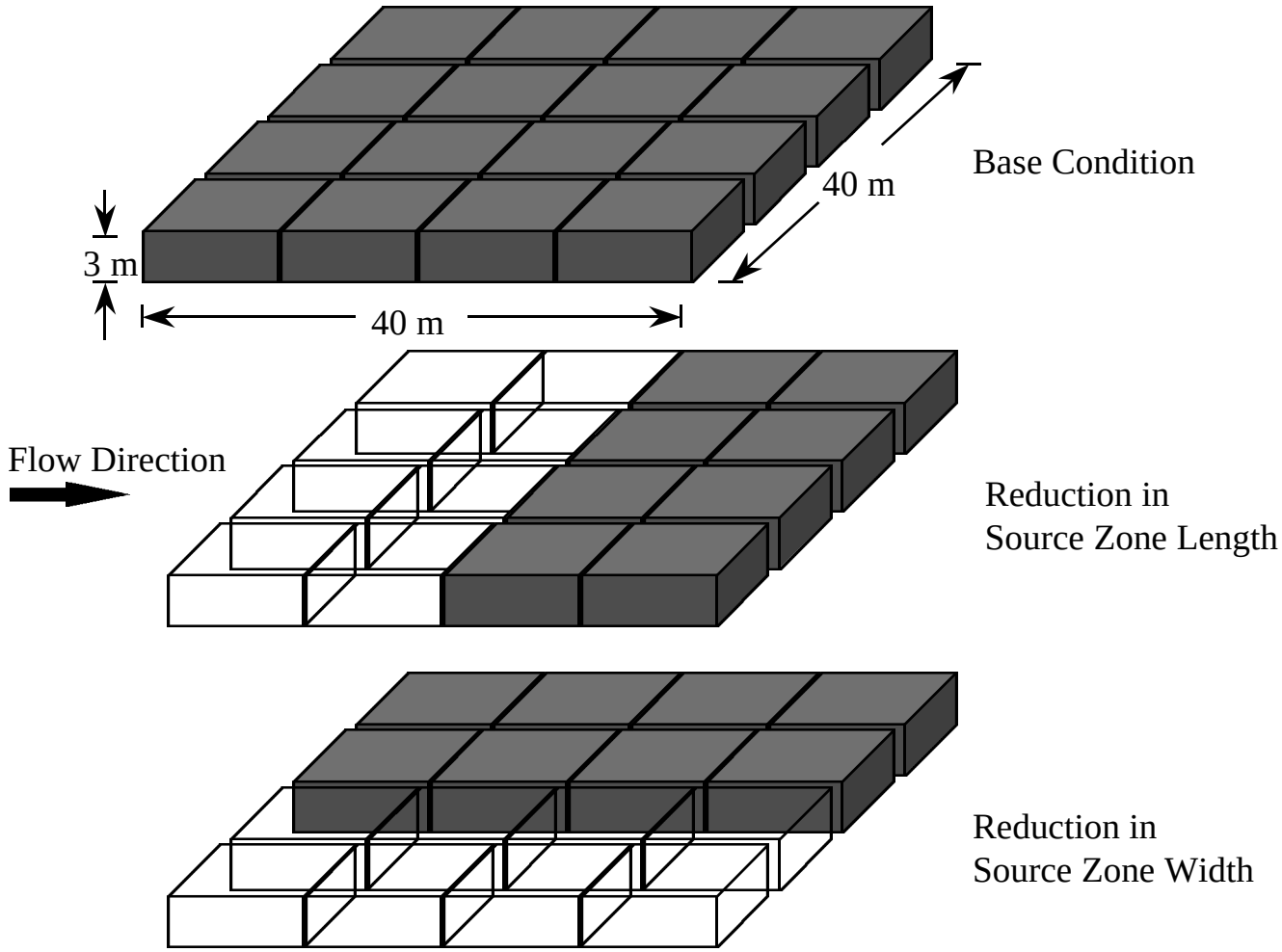
Source Zone Conceptualization

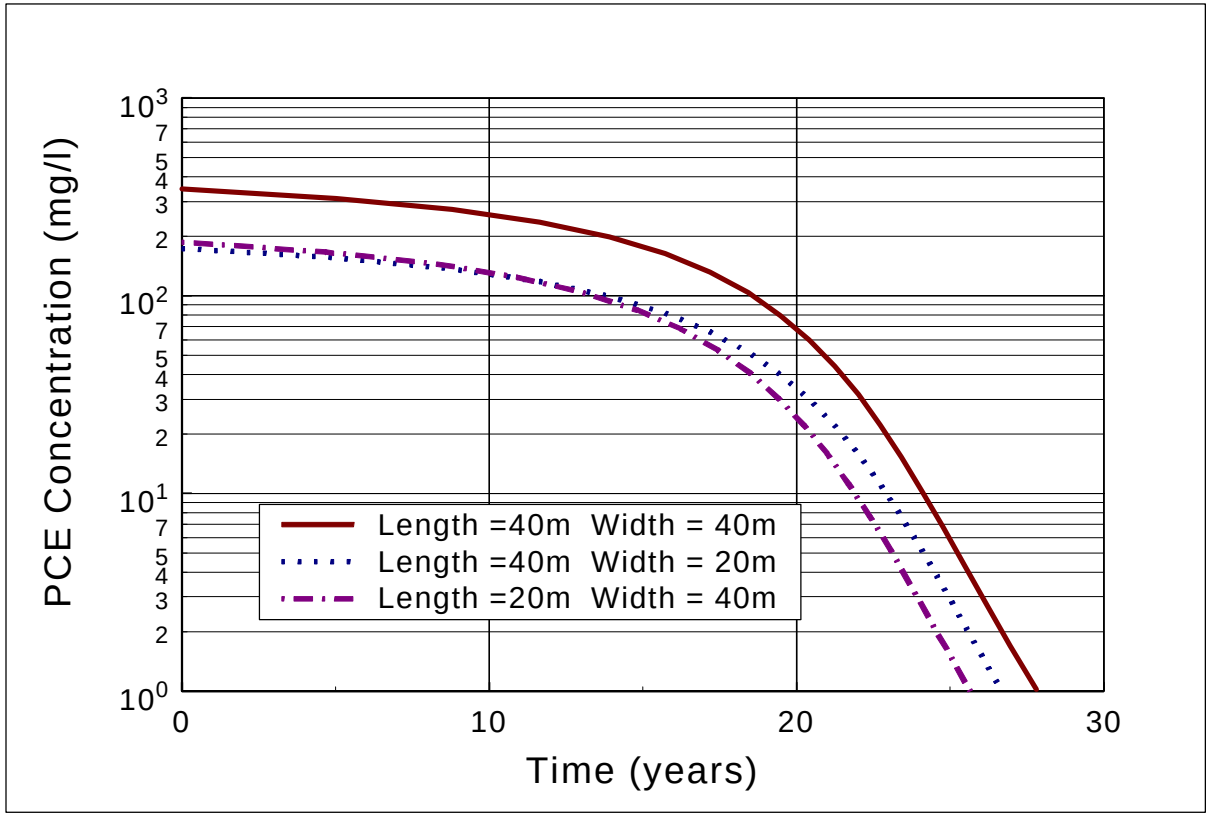


U.S. AIR FORCE

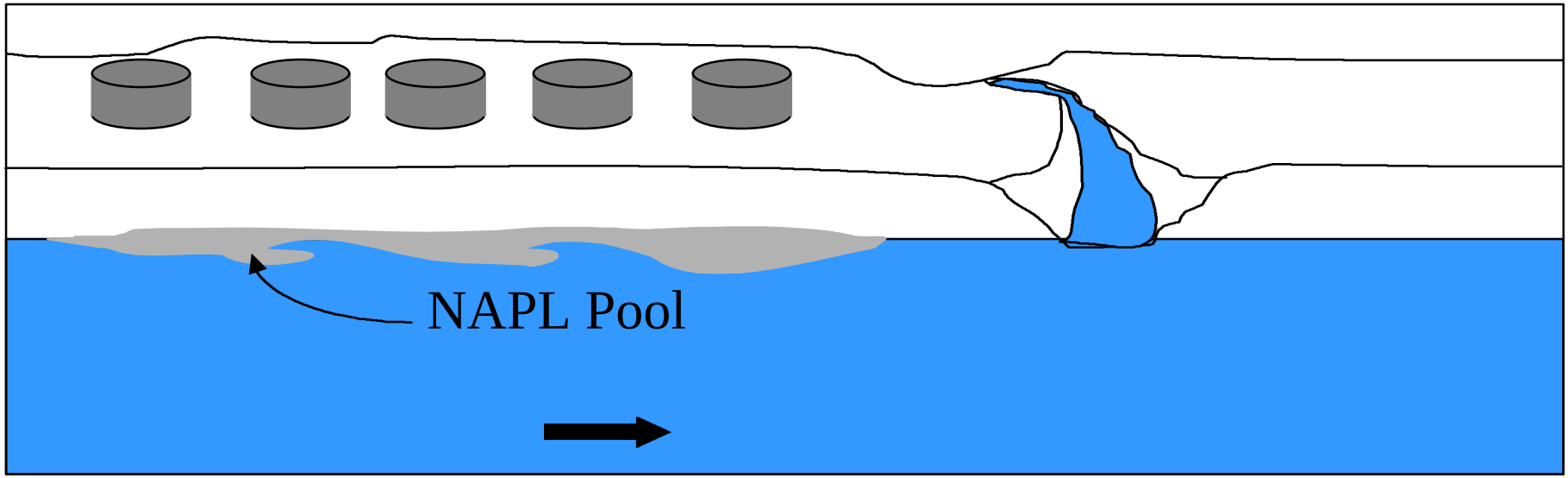
Mass transfer and normalized effluent concentration as a function of bulk subzone fraction (data fit to 90% confidence limits)




3 m
40 m
40 m
Base Condition
Flow Direction
Reduction in
Source Zone Length
Reduction in
Source Zone Width

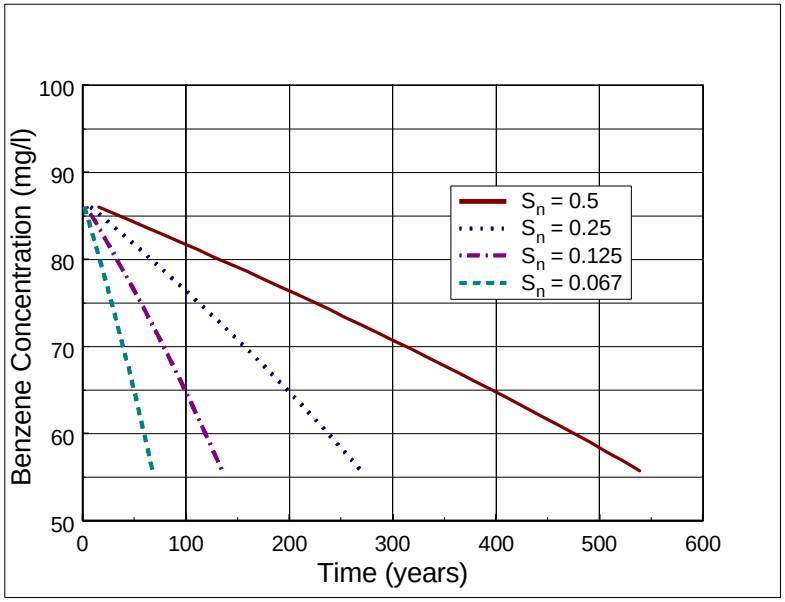

PCE Concentration (mg/l)
10^3
7
5
4
3
2
10^2
7
5
4
3
2
10^1
7
5
4
3
2
10^0
0
10
20
30
Time (years)
Length =40m Width = 40m
Length =40m Width = 20m
Length =20m Width = 40m

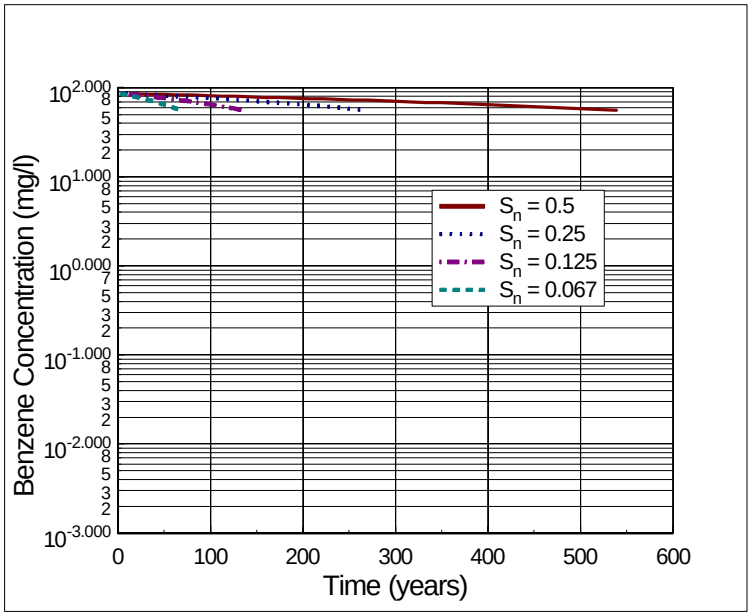
Virtual Refinery



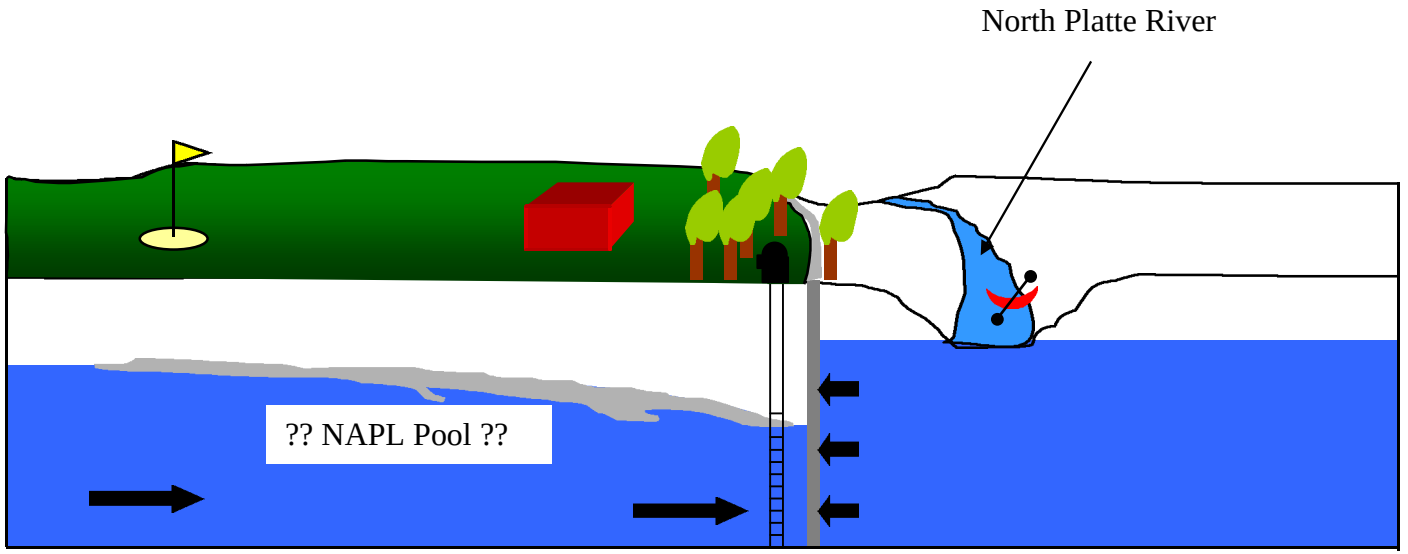
Pool Length = 1500 ft
Pool Height = 1 ft
Seepage Velocity = 150 ft/yr
Porosity = 0.25
NAPL Saturation = 0.5
Mole Fraction Benzene = 0.1

Effects of source zone remediation on groundwater quality and source longevity



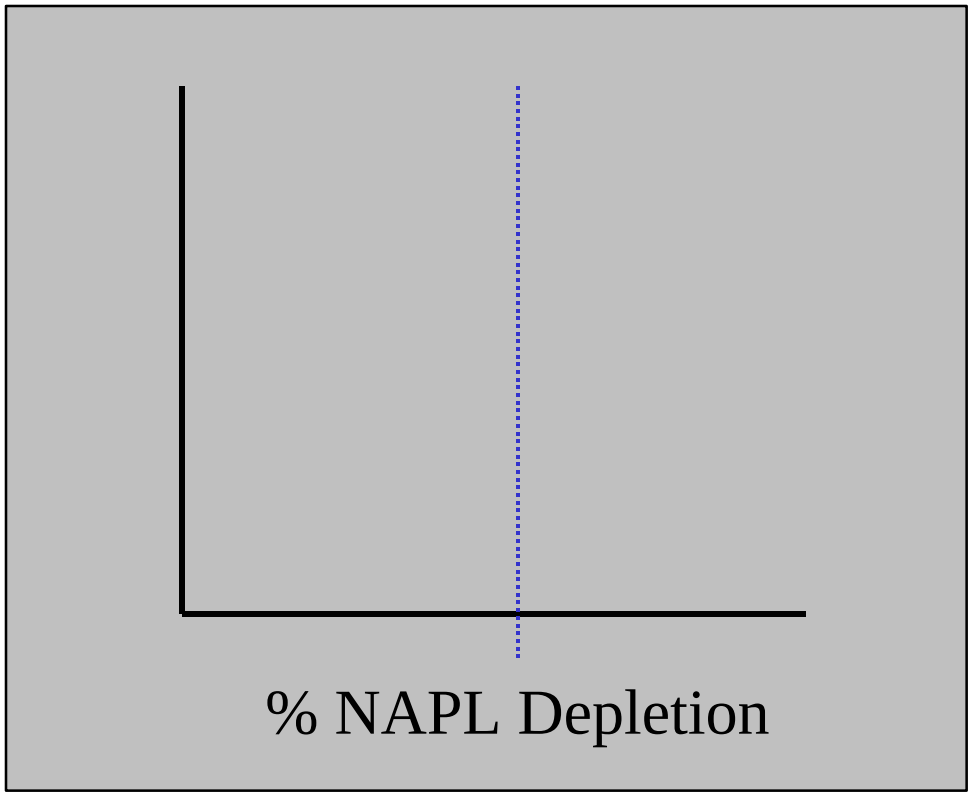


Summary of Key Issues



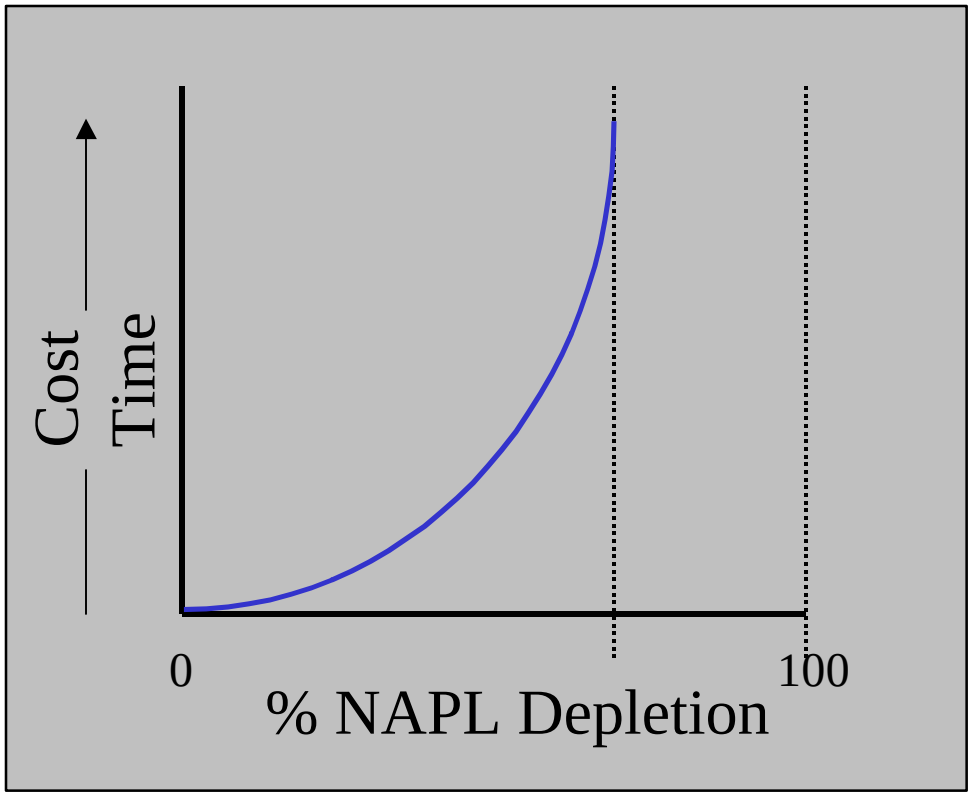
Prognosis: What can we expect from forced advection technologies?

1) With proven technologies 40-60 % DNAPL recovery appears to be recovery to the maximum extent possible.



Prognosis - Endpoints

2) Maximum potential depletion will be approached asymptotically with increasing cost and time



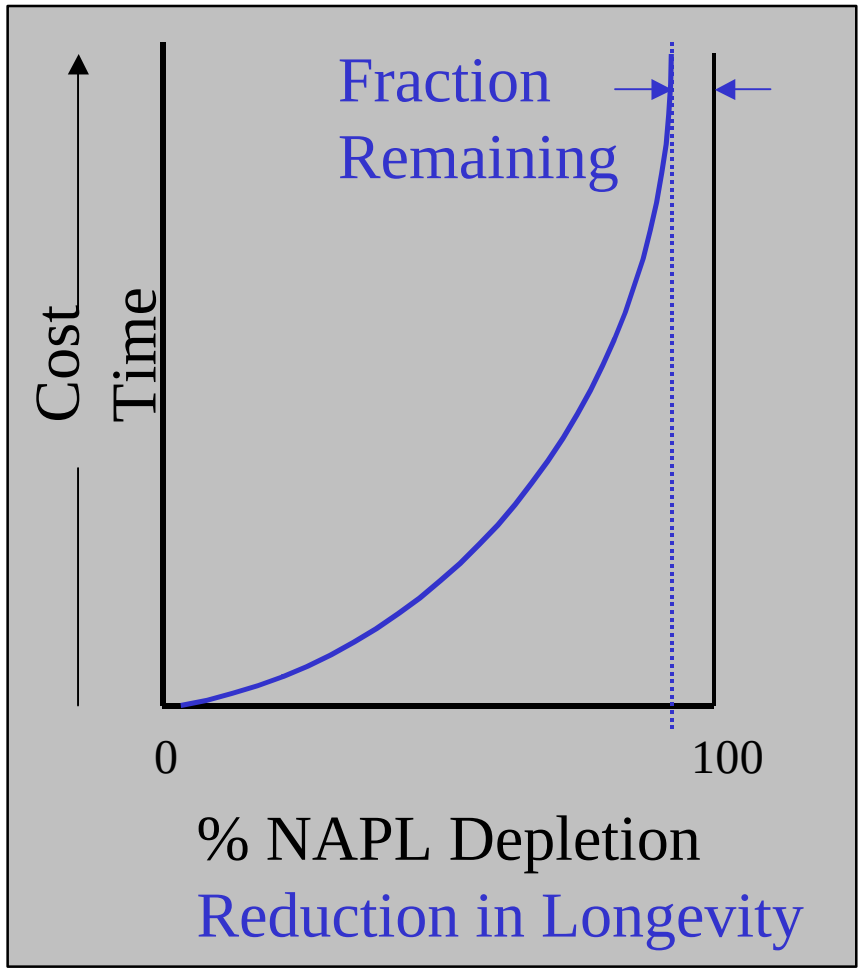
Prognosis - Niche

3) With emerging technology even 90% depletion will do little to alter near-term site care requirements

4) In the absence of clear benefits the high cost of emerging technologies are limiting large applications

5) The best roles for proven forced advection technologies:

- •Stabilization
- •Reduction in source longevity



U.S. AIR FORCE

Path Forward

Containment - Feasible

Renovation Consistent with Reuse
- A reasonable near-term goal

Restoration The Ultimate Goal
- When proven technologies exist