Capping for Management of Contaminated Sediments and Dredging Residuals

Carlos E. Ruiz, PhD

Paul R. Schroeder, PhD, PE

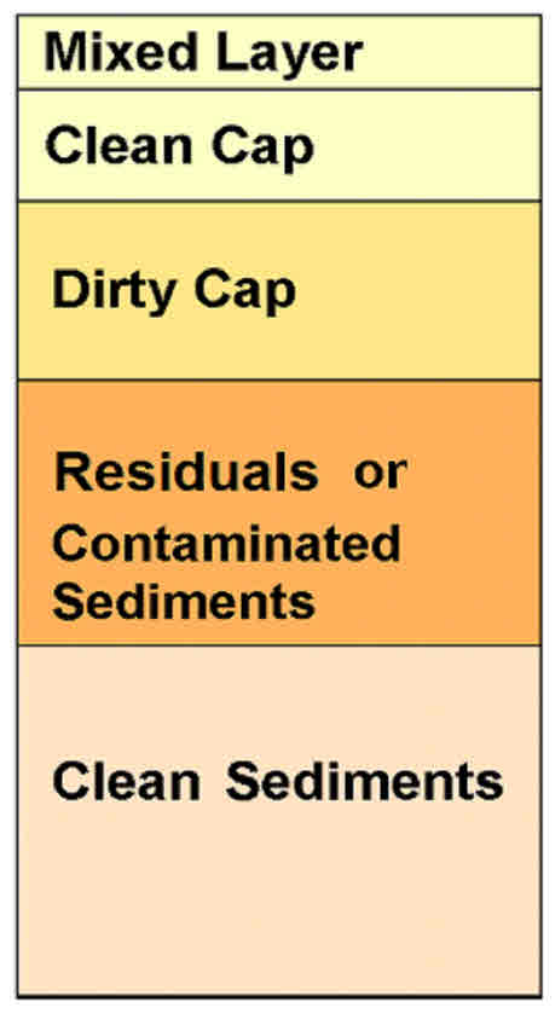
Thomas D. Borrowman

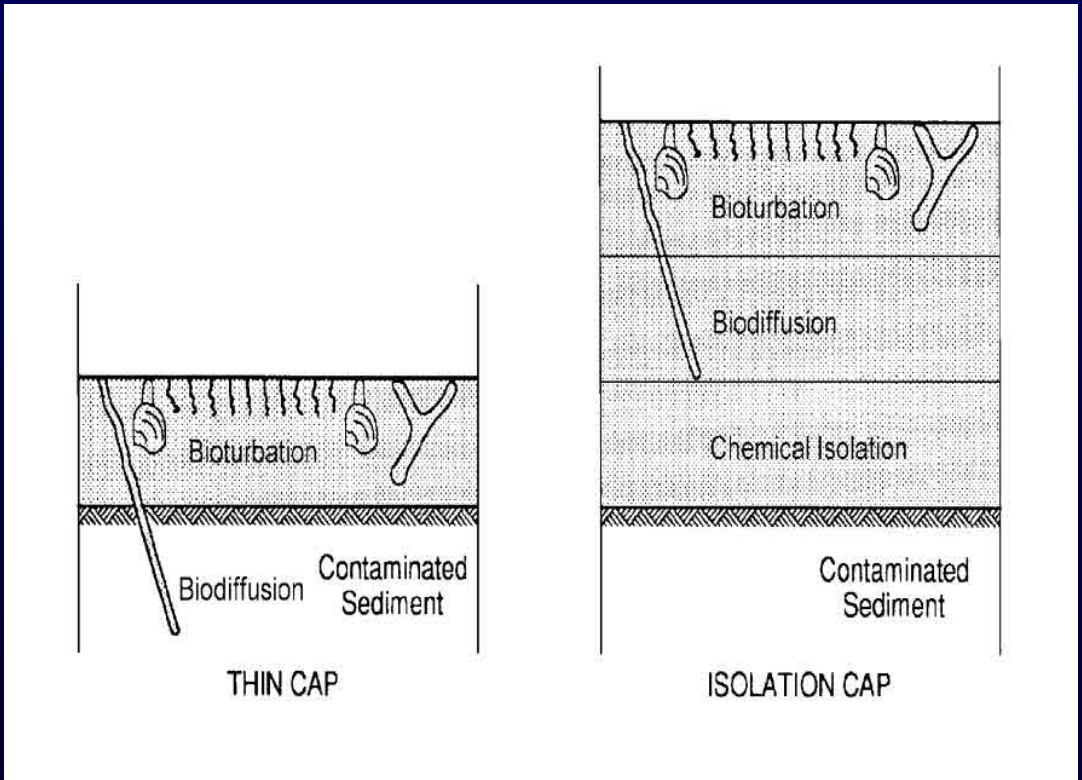
U.S. Army Engineer Research and Development Center, Vicksburg, MS

5th International SedNet Conference 27-29 May 2008, Oslo, Norway

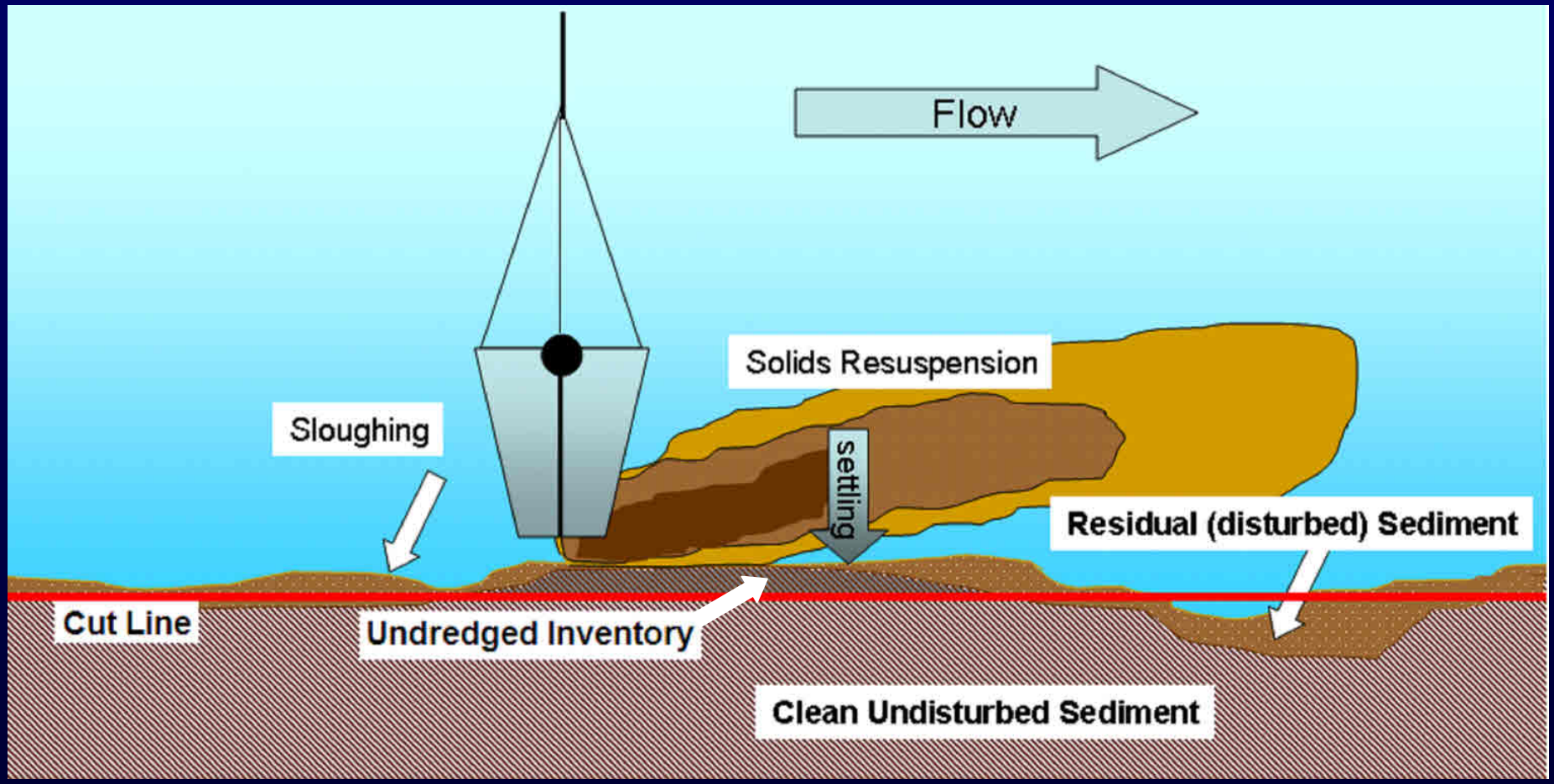
What is Capping?

- Placement of Media on Surface to
  - Provide Isolation
  - Reduce Bioavailability

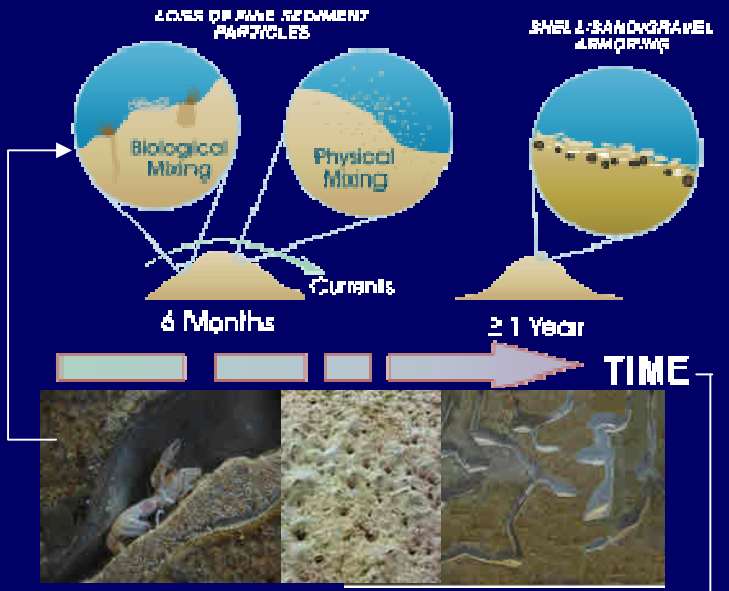


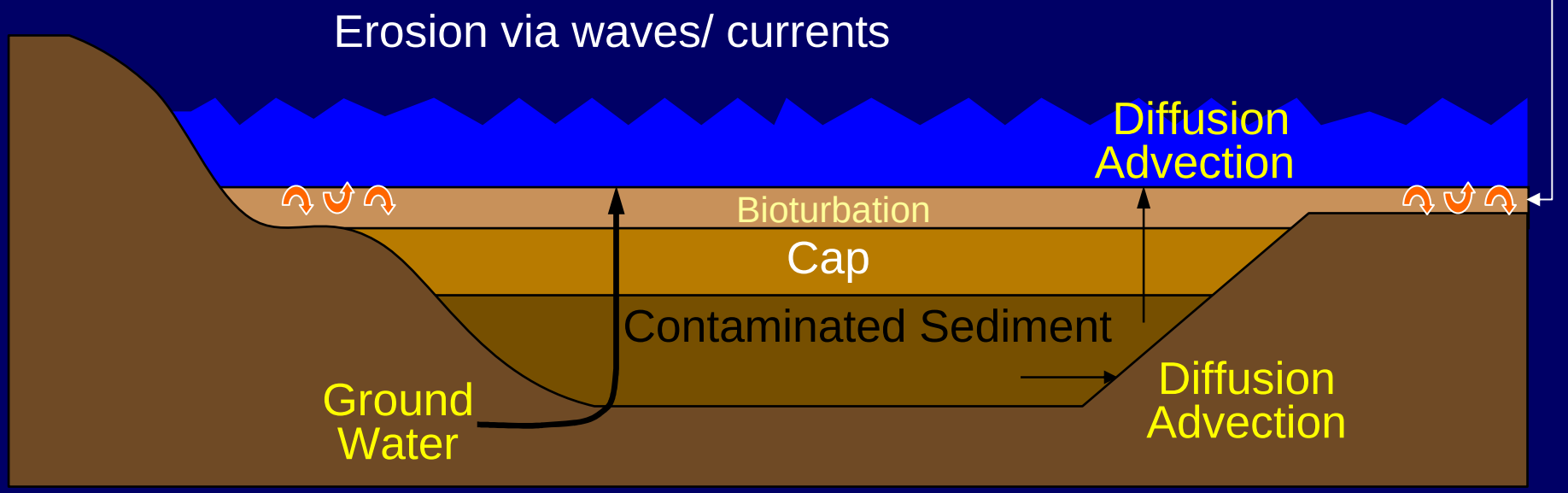


What are Residuals?



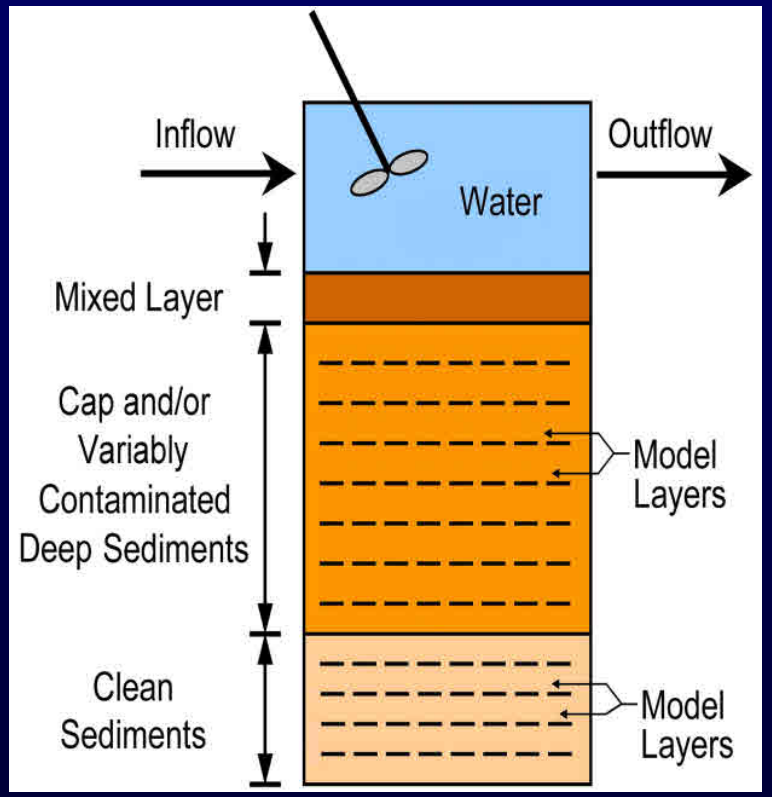
Migration Pathways for Capping





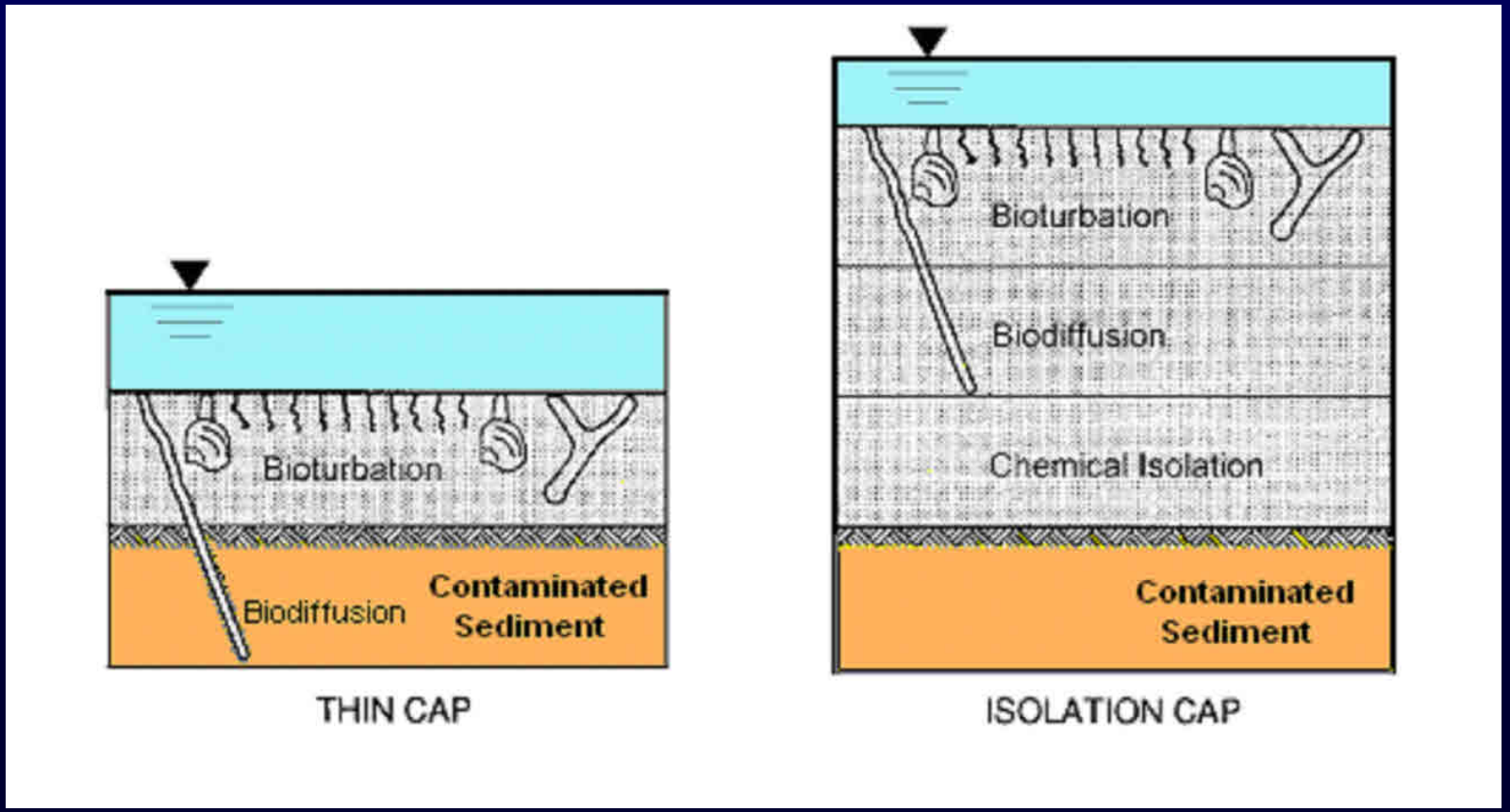
USACE RECOVERY Model

- PC based, user friendly
- Fully mixed water body and layered bottom sediments
- Time-variable
- Organic contaminants database
- Computes sediment and water contaminant concentrations and fluxes vs. time
- Assumes reversible linear equilibrium sorption and first order decay kinetics

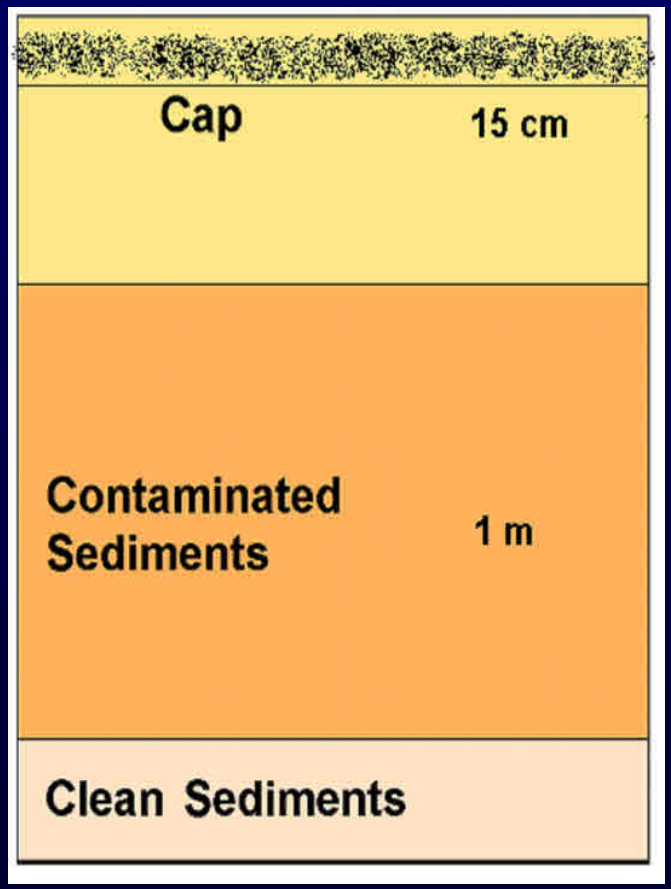


Engineered Reduction in Bioavailability

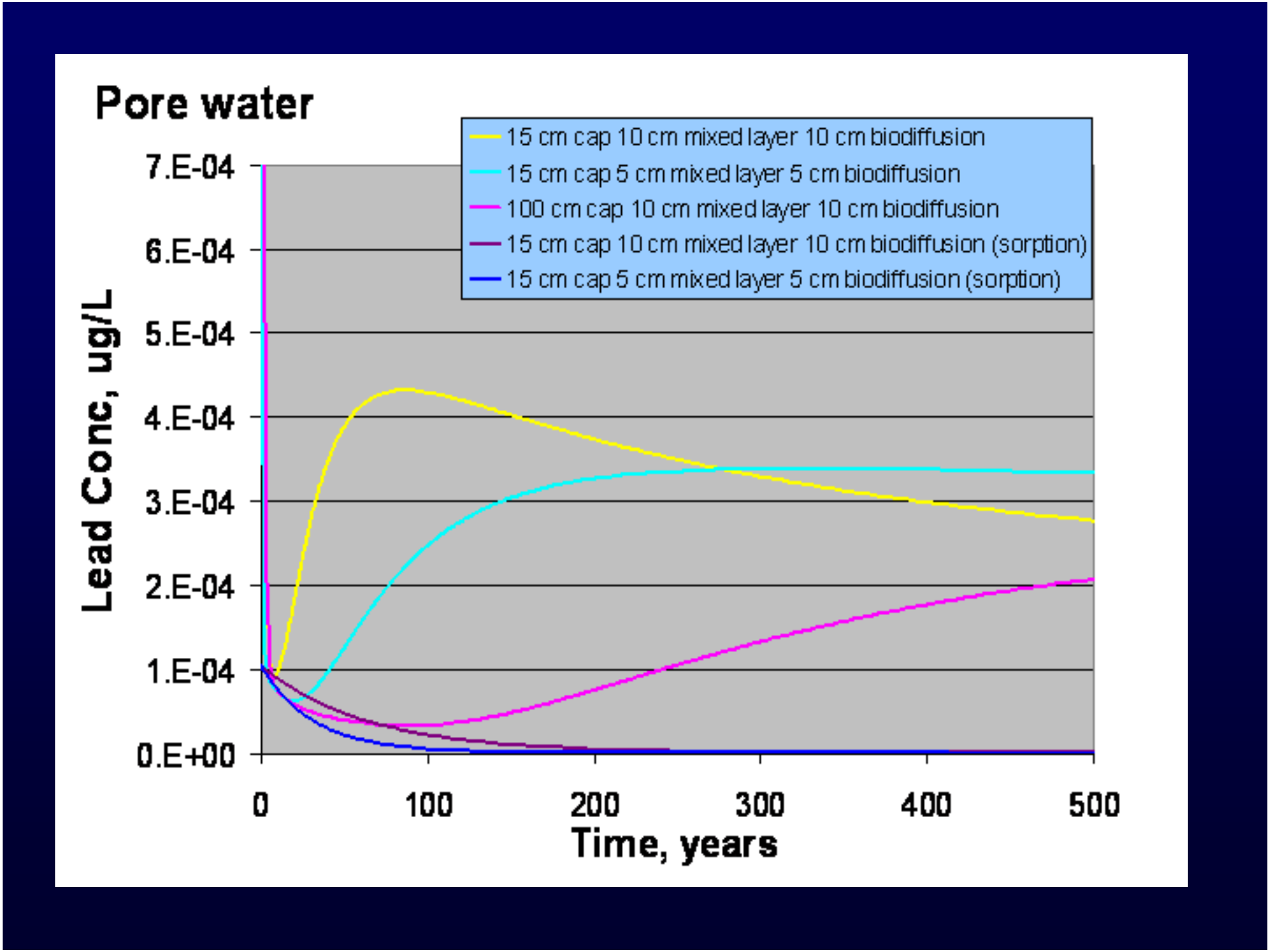
Comparison of Cap Thickness and Media

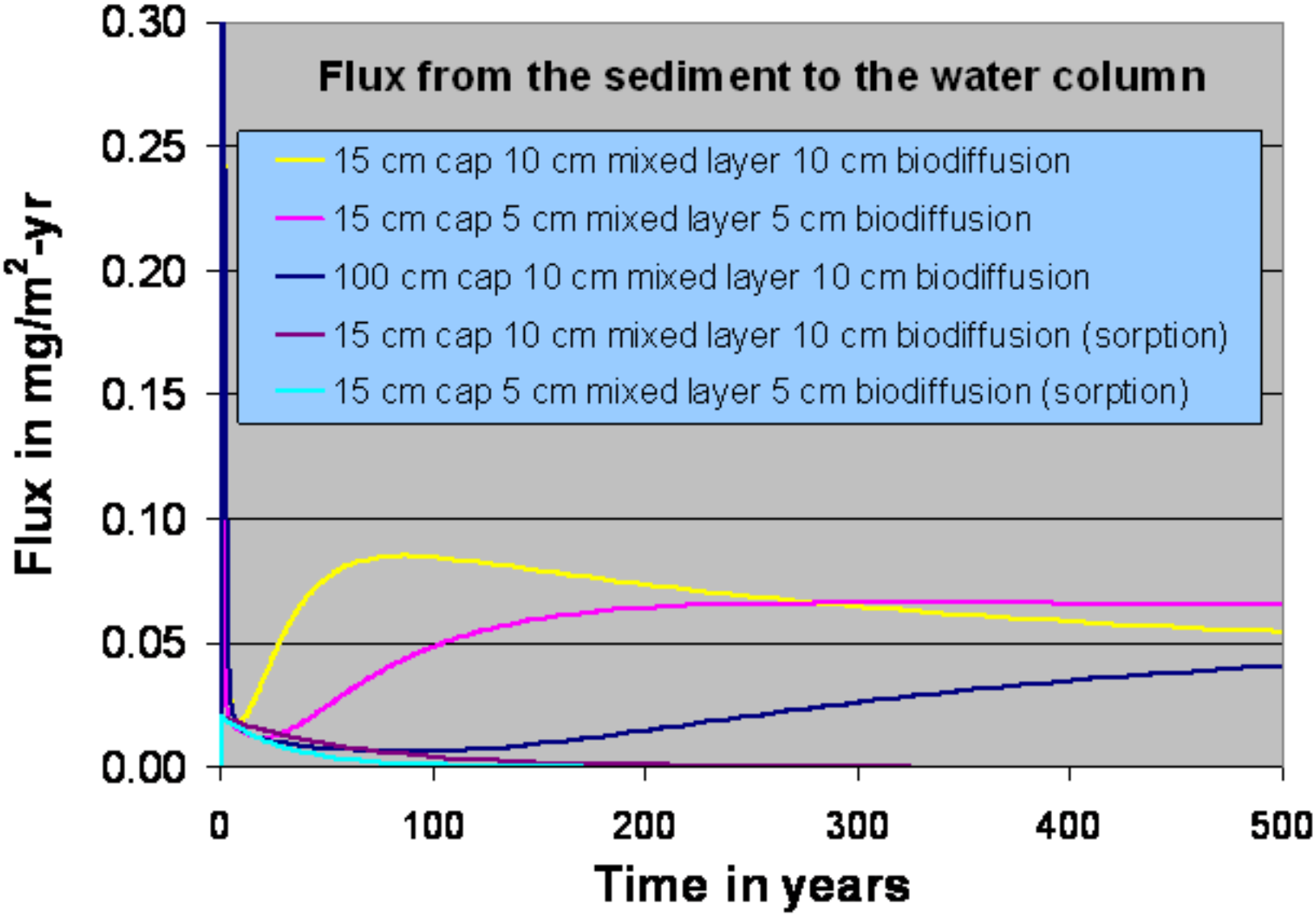


Values Used in the Parametric Evaluation



Parameter	Value
Mixed layer thickness (cm)	5 and 10
Cap thickness (cm)	15 and 100
Porosity of cap	0.5
Specific gravity of cap	2.67
Kd for the cap	1 and 1000
Initial contaminant conc in cap (mg/kg)	0.2
Sediment thickness (m)	1
Porosity of sediment	0.67
Specific gravity of sediment	2.54
Kd for the sediment	10
Initial contaminant conc in sediment (mg/kg)	100
Settling velocity (m/yr)	26
Burial velocity (m/yr)	0.00003
Molecular diffusivity (cm2/sec)	5x10-6
Biodiffusion coefficient (cm2/sec)	2x10-5
Biodiffusion depth (cm)	5 and 10

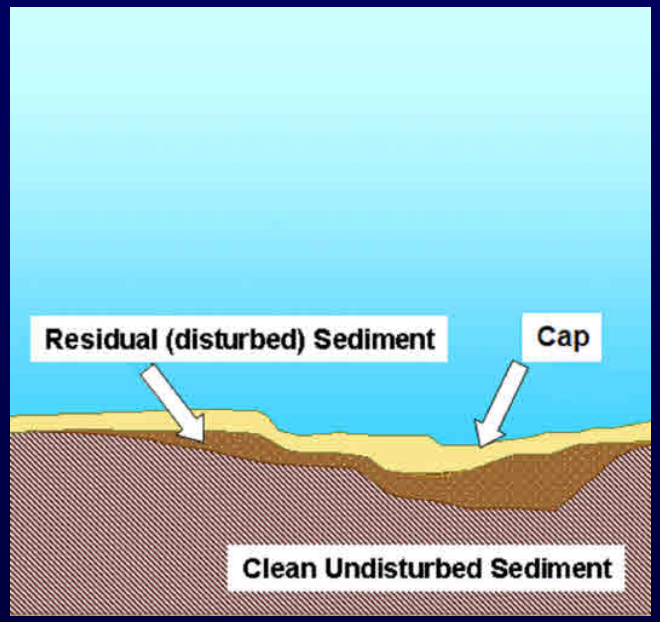

Pore water
15 cm cap 10 cm mixed layer 10 cm biodiffusion
15 cm cap 5 cm mixed layer 5 cm biodiffusion
100 cm cap 10 cm mixed layer 10 cm biodiffusion
15 cm cap 10 cm mixed layer 10 cm biodiffusion (sorption)
15 cm cap 5 cm mixed layer 5 cm biodiffusion (sorption)
Lead Conc, ug/L
7.E-04
6.E-04
5.E-04
4.E-04
3.E-04
2.E-04
1.E-04
0.E+00
0
100
200
300
400
500
Time, years


Flux from the sediment to the water column
15 cm cap 10 cm mixed layer 10 cm biodiffusion
15 cm cap 5 cm mixed layer 5 cm biodiffusion
100 cm cap 10 cm mixed layer 10 cm biodiffusion
15 cm cap 10 cm mixed layer 10 cm biodiffusion (sorption)
15 cm cap 5 cm mixed layer 5 cm biodiffusion (sorption)
Flux in mg/m2-yr
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
100
200
300
400
500
Time in years

Conclusions

- Thin sand caps reduced contaminant flux and pore water concentration for lead (a Kd of 1 in the sand cap) by a factor of 50 initially and by at least a factor of 20 in the long term
- Thick sand caps further reduced contaminant flux and pore water concentration of lead by a factor of 3 initially and less than a factor of 1.5 in the long term
- Both immediately reduced the surficial sediment concentration by a factor of 500 and would not be contaminated above the initial by the capped sediment
- The sorptive caps reduce the bioavailability of contaminated sediments by a factor of about 100 more than all of the sand caps over the long term

Capping Residuals

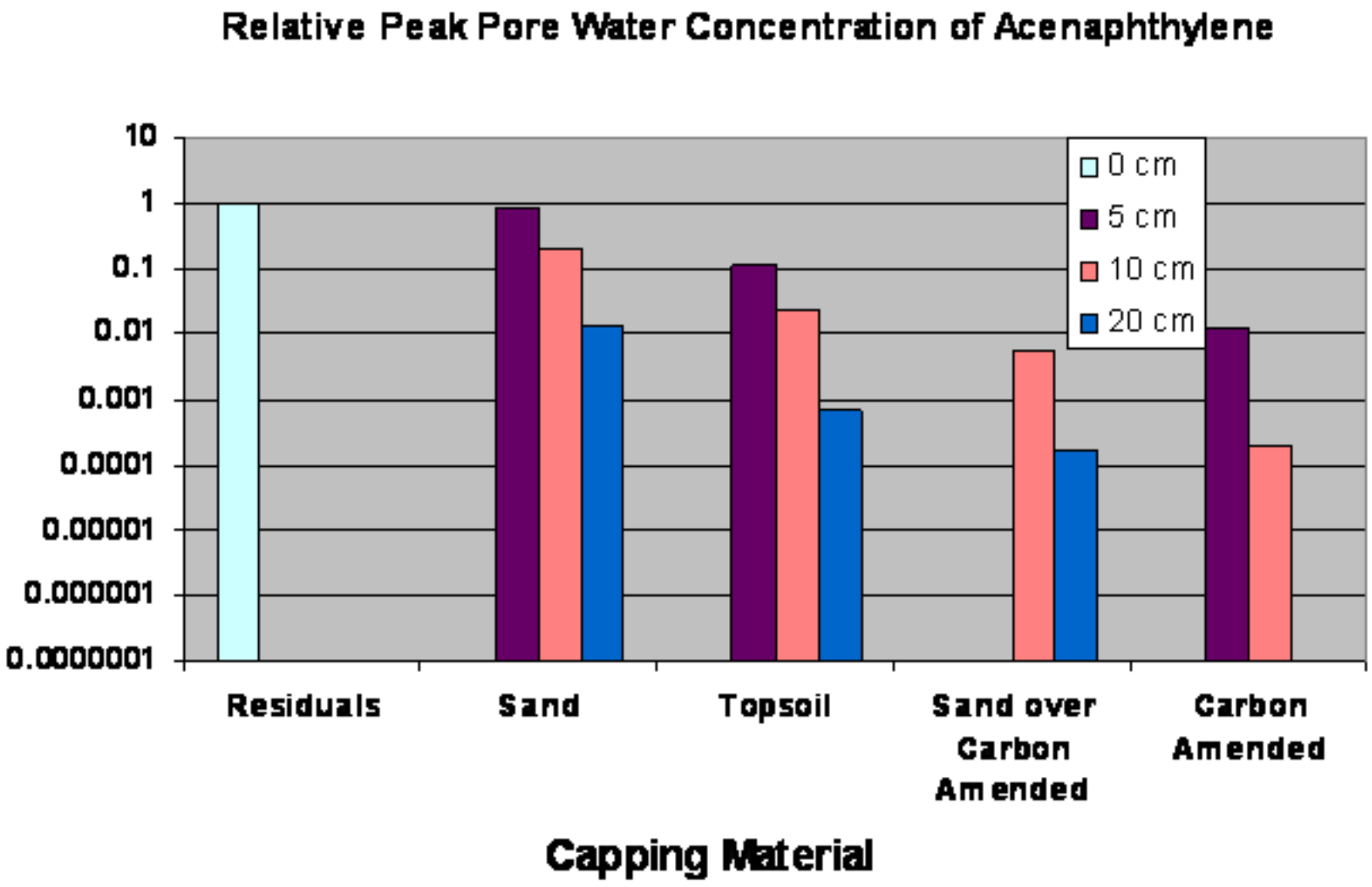


Parameter	Values
Cap Thickness	0, 5, 10, 20 cm
Capping Media	Sand Topsoil Carbon Sand Mixture Sand over Carbon Sand Mixture
Contaminant	Acenaphthylene
Kow	5010

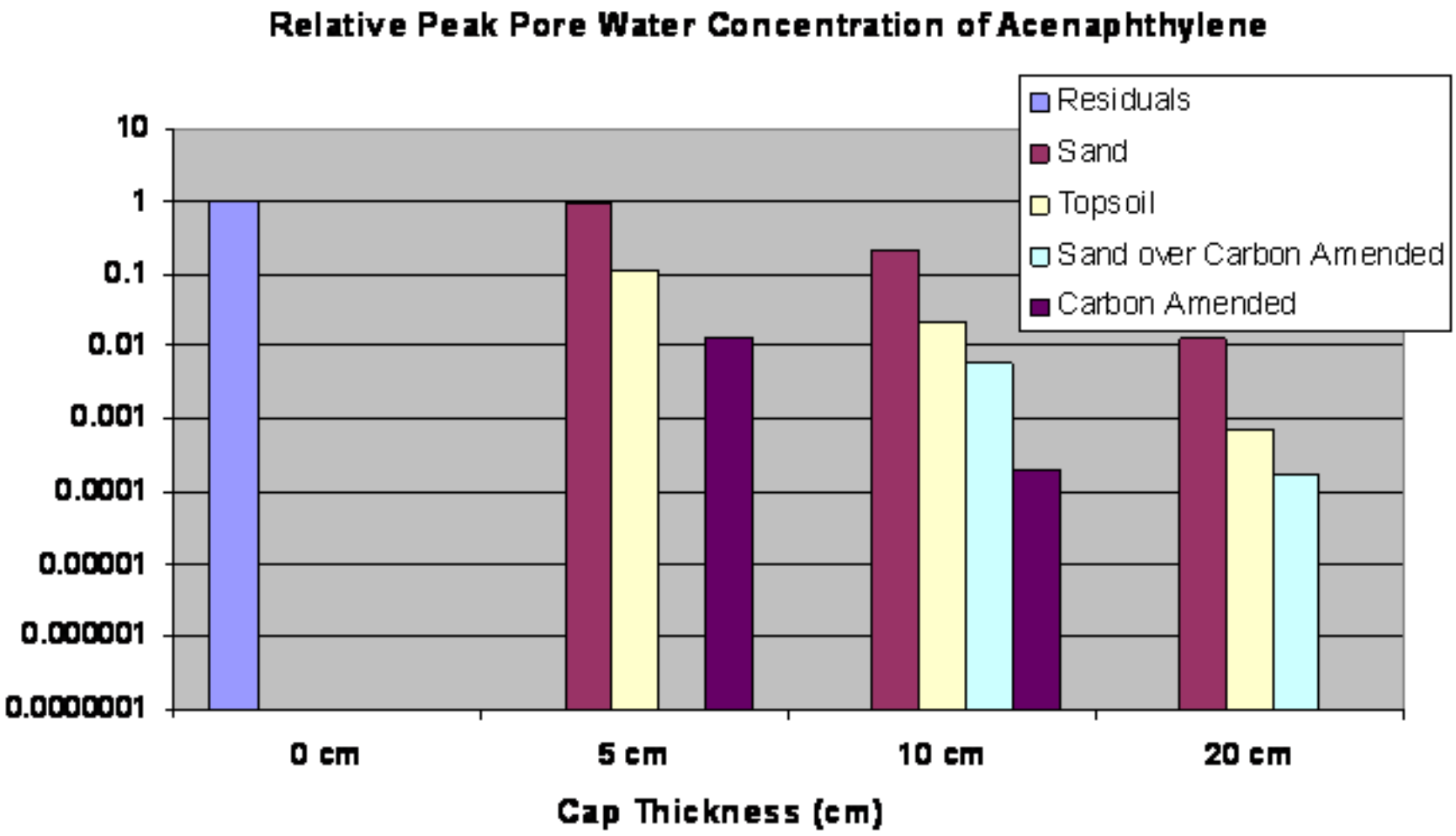
Properties

Material	Porosity	FOC
Residuals	0.85	0.05
Dirty Sand	0.6	0.008
Dirty Topsoil	0.8	0.05
Dirty Carbon/Sand	0.6	0.6
Clean Sand	0.6	0.003
Clean Topsoil	0.8	0.05
Clean Carbon/Sand	0.6	0.6

Effects of Cap Thickness

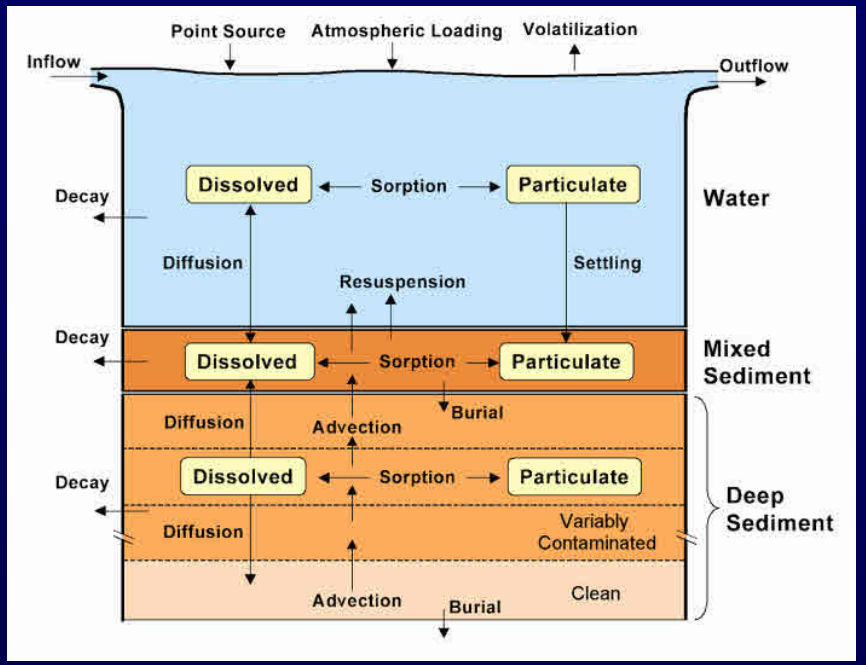


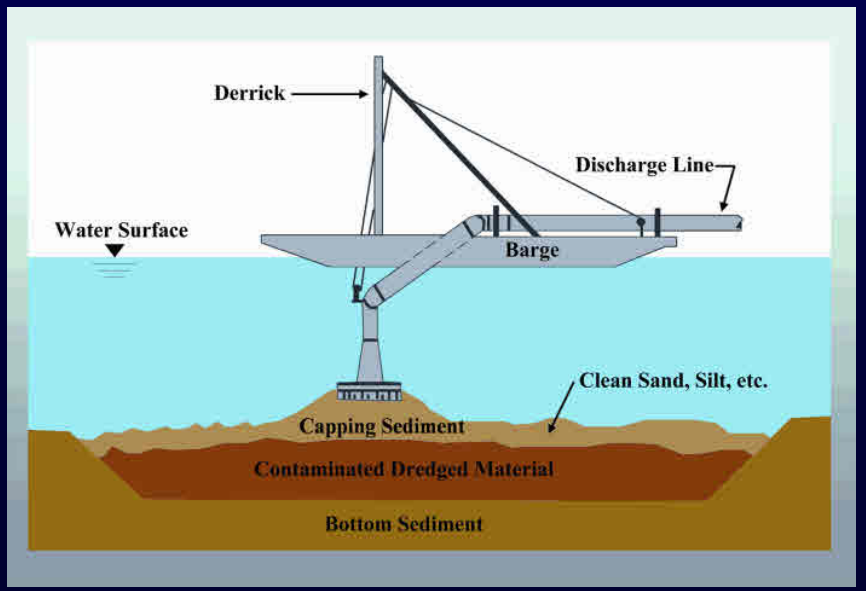
Effects of Capping Media



CAP Model

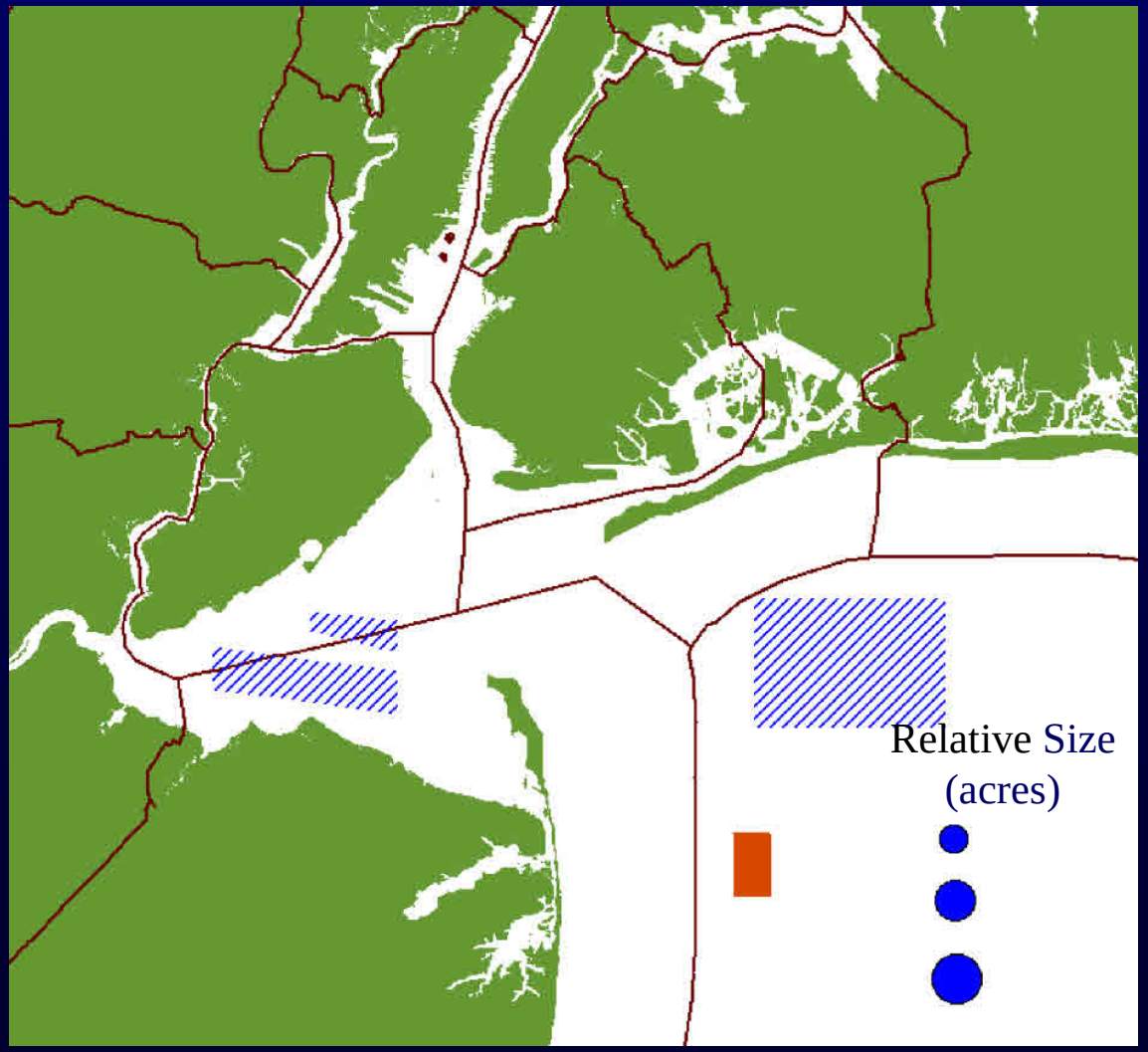
- Extension of the RECOVERY model
- Couples consolidation predictions by the PSDDF model with contaminant transport (PSDDF is USACE dredged material consolidation model)
- Addresses short-term advection from consolidation and long-term diffusion and groundwater advection of contaminants



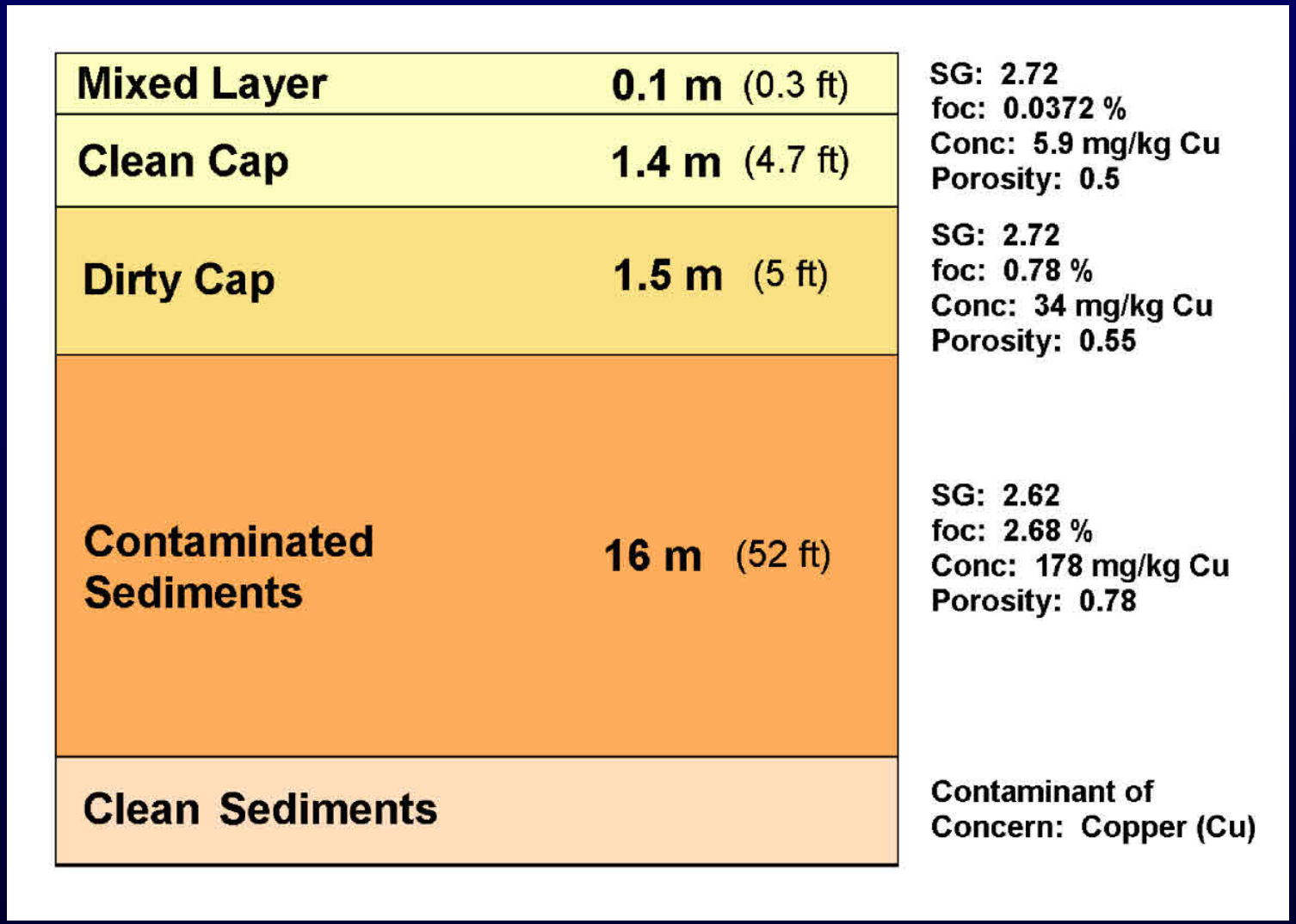


NY Confined Aquatic Disposal (CAD) Sites: An Application of the CAP Model

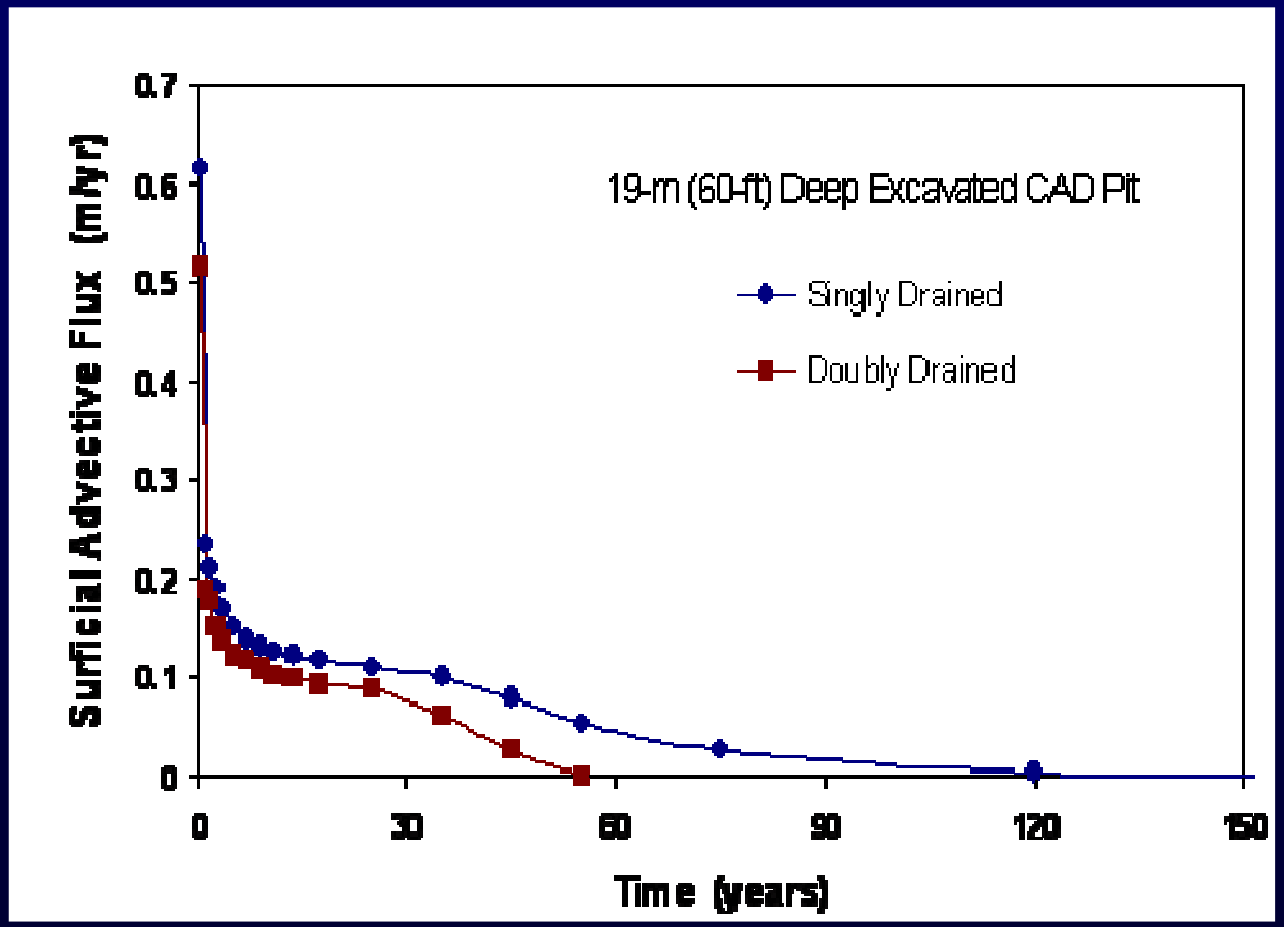
- **Each pit would be filled and capped during a dredging season**
- **10 ft cap (isolation)**
- **60 ft deep pit**
- **Water depth range from 15-35 ft**



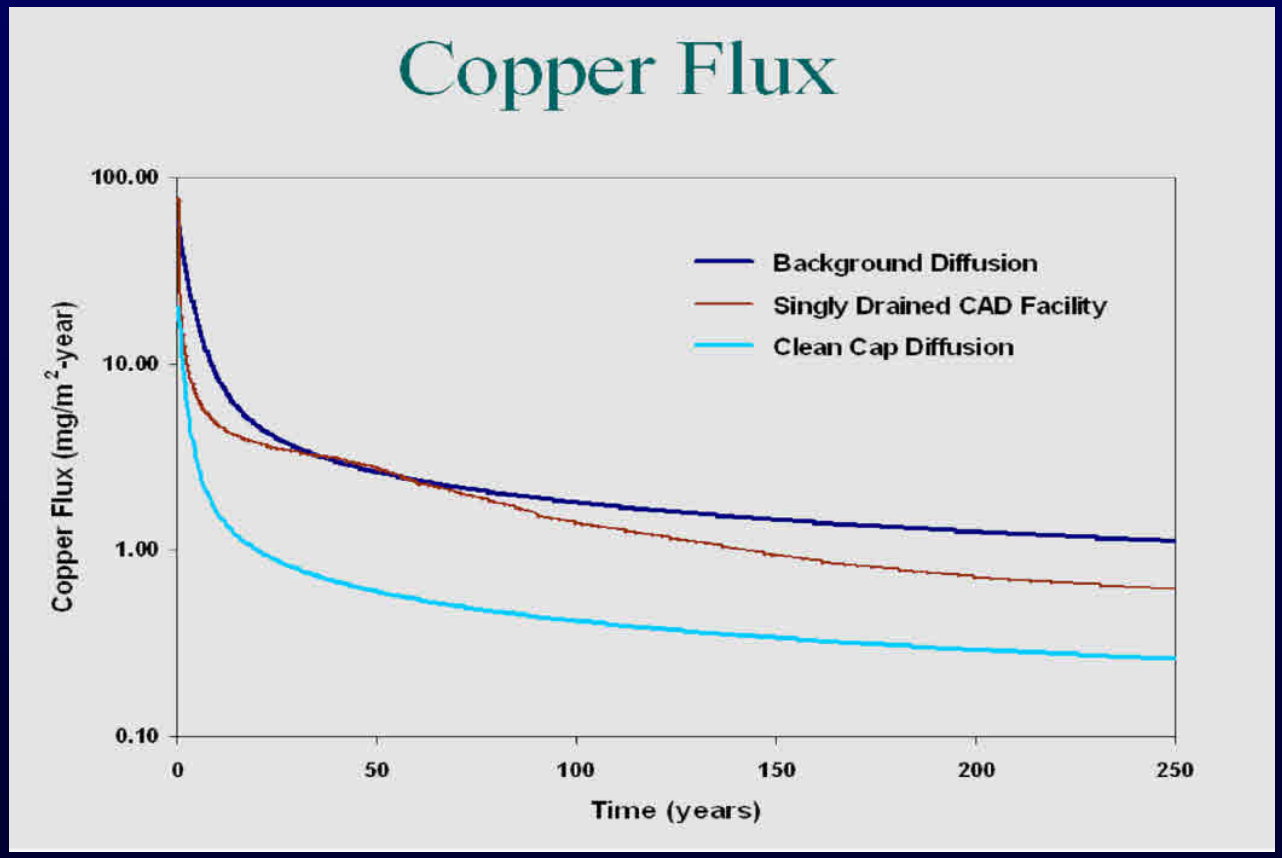
CAD Facility Conceptual Model



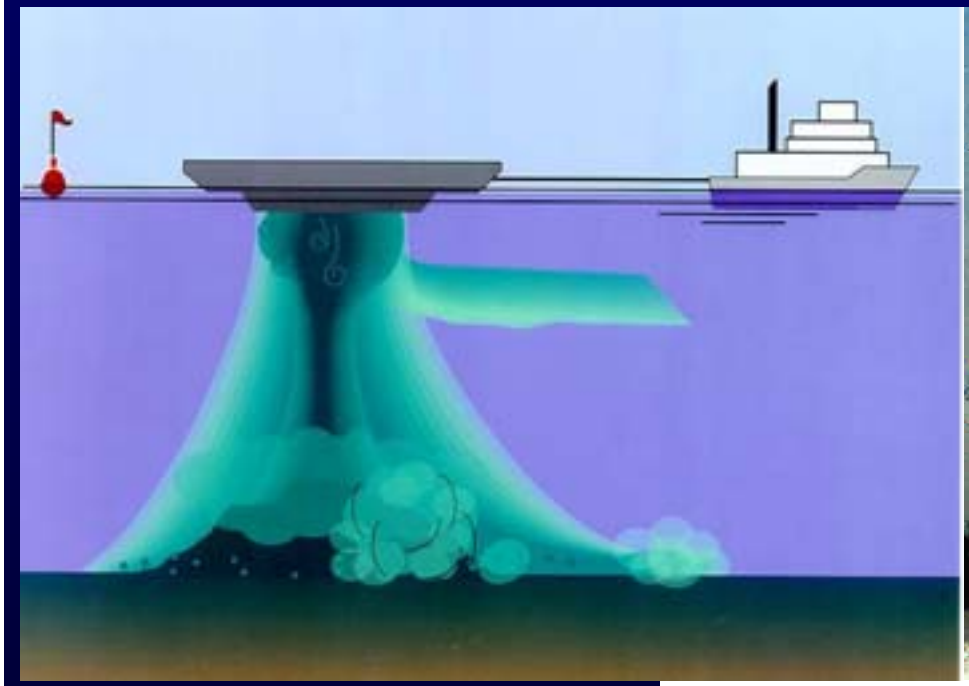
NY CAD Evaluation: Advective Flux



NY CAD Evaluation: Contaminant Flux Comparisons



Questions?



CAP IT

CAP IT