# CALIFORNIA PERSPECTIVE ON VAPOR INTRUSION

***Association of State and Territorial Solid Waste Management Officials***

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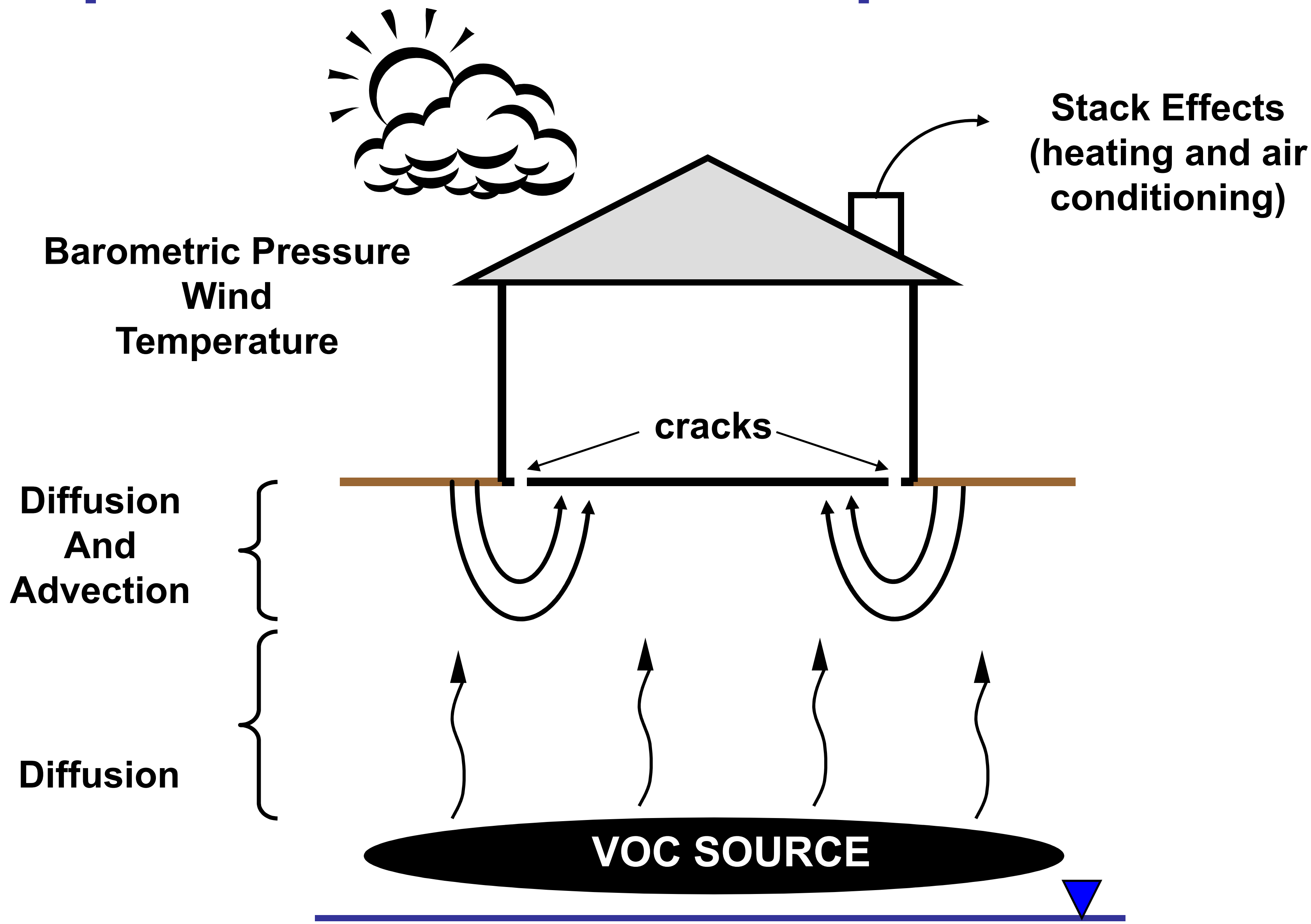
# Vapor Intrusion – Conceptual Model



# Definition of Attenuation Factor

$$\textbf{attenuation factor } (\alpha) = \frac{\textbf{indoor air concentration}}{\textbf{soil gas concentration}}$$

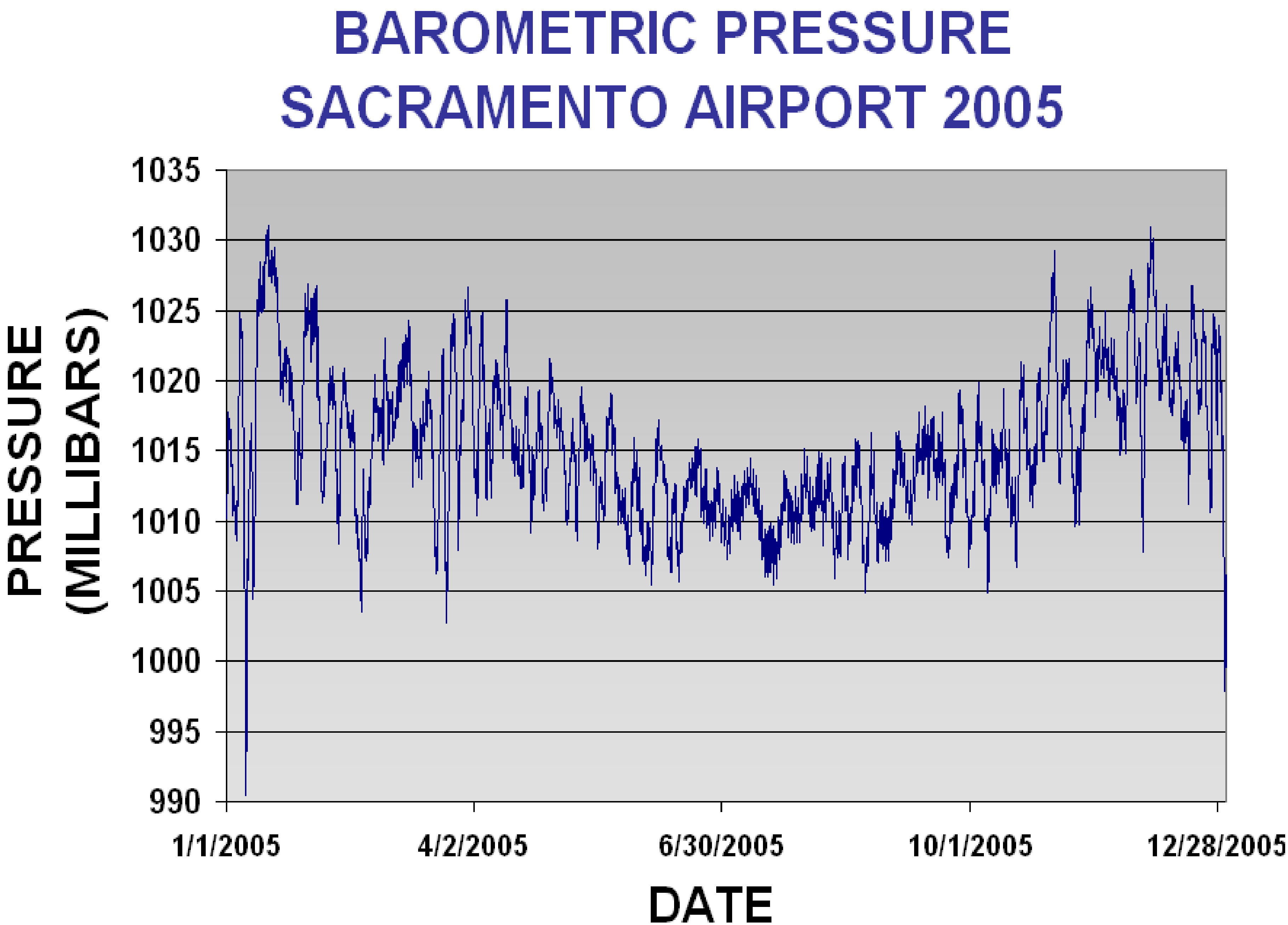
# California Guidance Documents for Vapor Intrusion

- **Advisory – Active Soil Gas Investigations (DTSC / LARWQCB, 2003)**
- **Human-Exposure-Based Screening Numbers for Contaminated Soil (OEHHA, 2004)**
- **Vapor Intrusion Guidance Document (DTSC, 2004)**
- **Vapor Intrusion Mitigation Guidance Document (DTSC, pending [2008])**

# BAROMETRIC PRESSURE

## DTSC Soil Gas Advisory (2003)

**"Sample depths should be chosen to minimize the effects of changes in barometric pressure, temperature, or breakthrough of ambient air from the surface"**



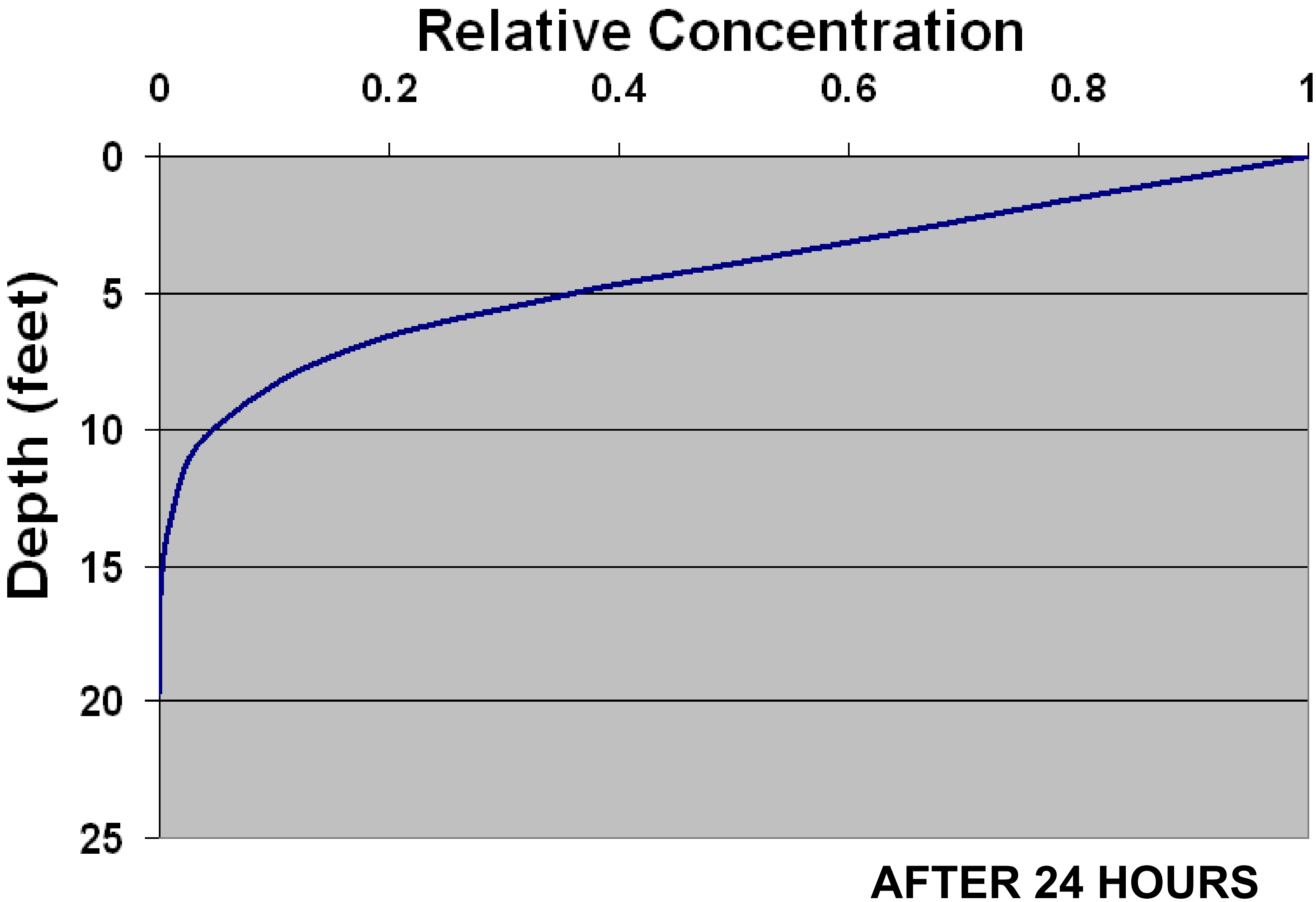
BAROMETRIC PRESSURE
SACRAMENTO AIRPORT 2005
PRESSURE (MILLIBARS)
1035
1030
1025
1020
1015
1010
1005
1000
995
990
1/1/2005
4/2/2005
6/30/2005
10/1/2005
12/28/2005
DATE

# BAROMETRIC PRESSURE

**Massman and Farrier (1992); used finite element numerical modeling to evaluate the movement of "fresh" air into the vadose zone due to barometric pumping**

- **Permeability = 1 x $10^{-7}$ $cm^2$ (sand)**
- **Porosity = 0.30**
- **Pressure change = 25 millibars**
- **Vadose zone thickness = 65 feet**
- **Period of pressure disturbance = 96 hours (sinusoidal)**

# FRESH AIR INTO VADOSE ZONE (Massman and Farrier, 1992)



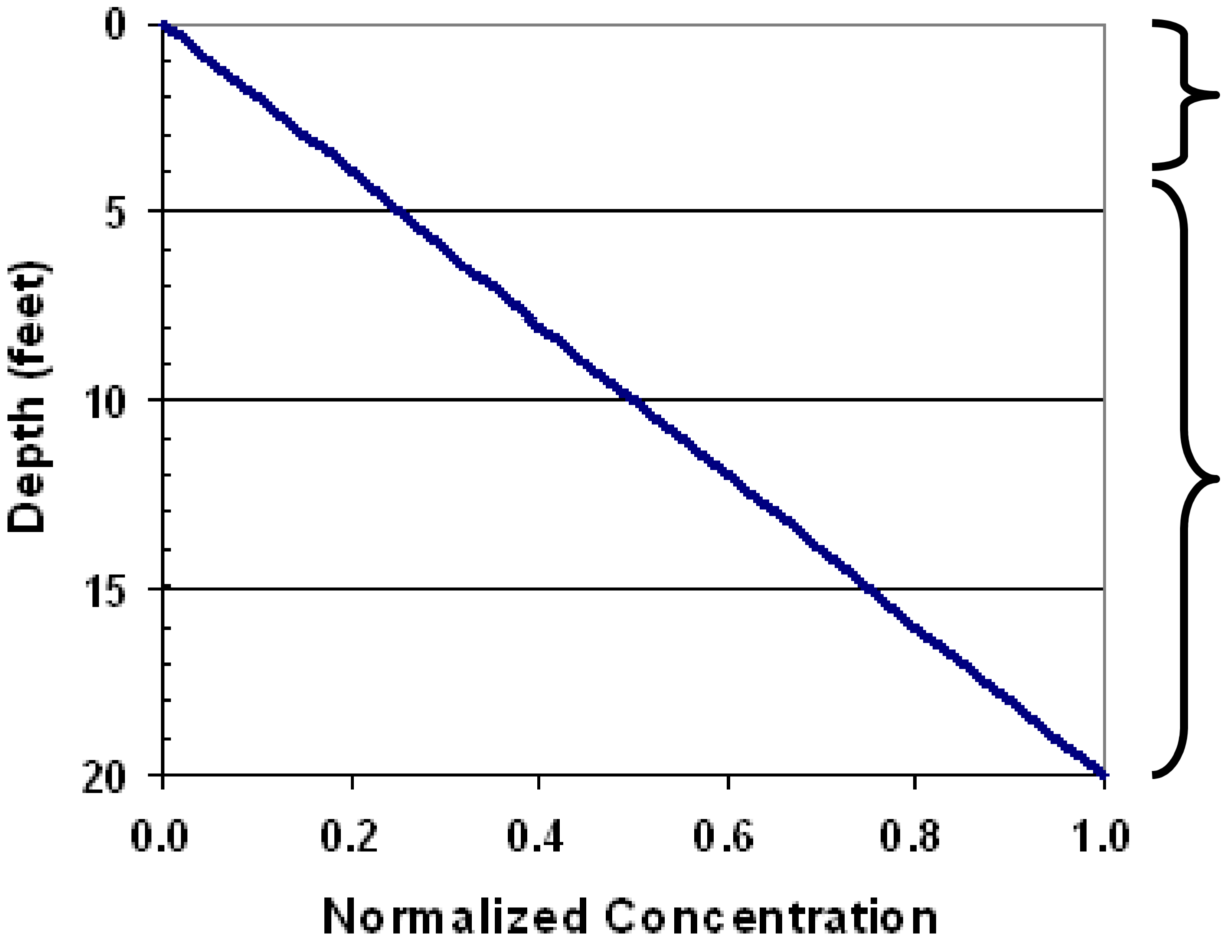
# RAINFALL

## DTSC Soil Gas Advisory (2003)

**"Soil gas sampling should not be conducted during or immediately after a significant rain event (1/2 inch or greater)"**

# Theoretical PCE Soil Gas Profile

**Johnson et al., 1999**

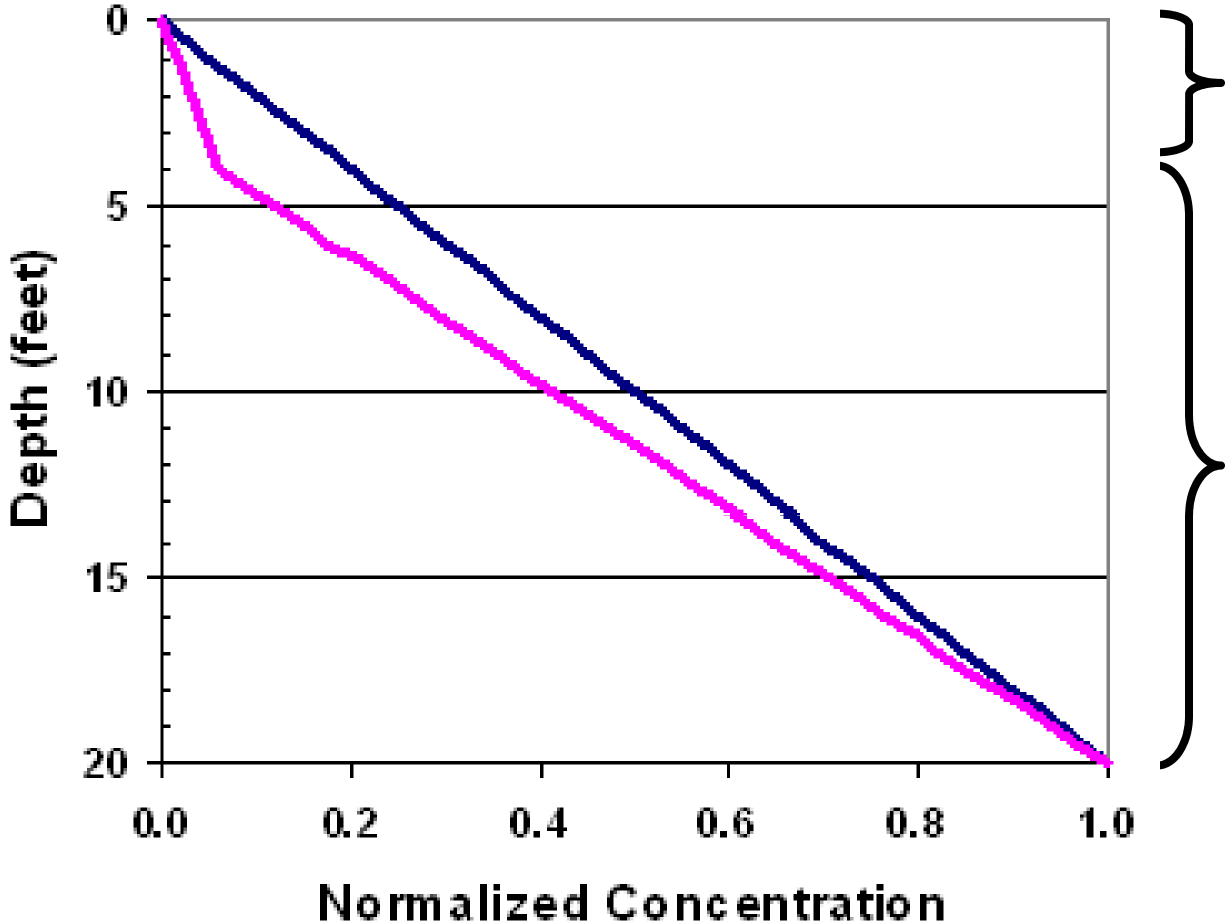



**Layer One**
**Porosity = 40%**
**Vol Water = 10%**

**Layer Two**
**Porosity = 40%**
**Vol Water = 10%**

# Theoretical PCE Soil Gas Profile

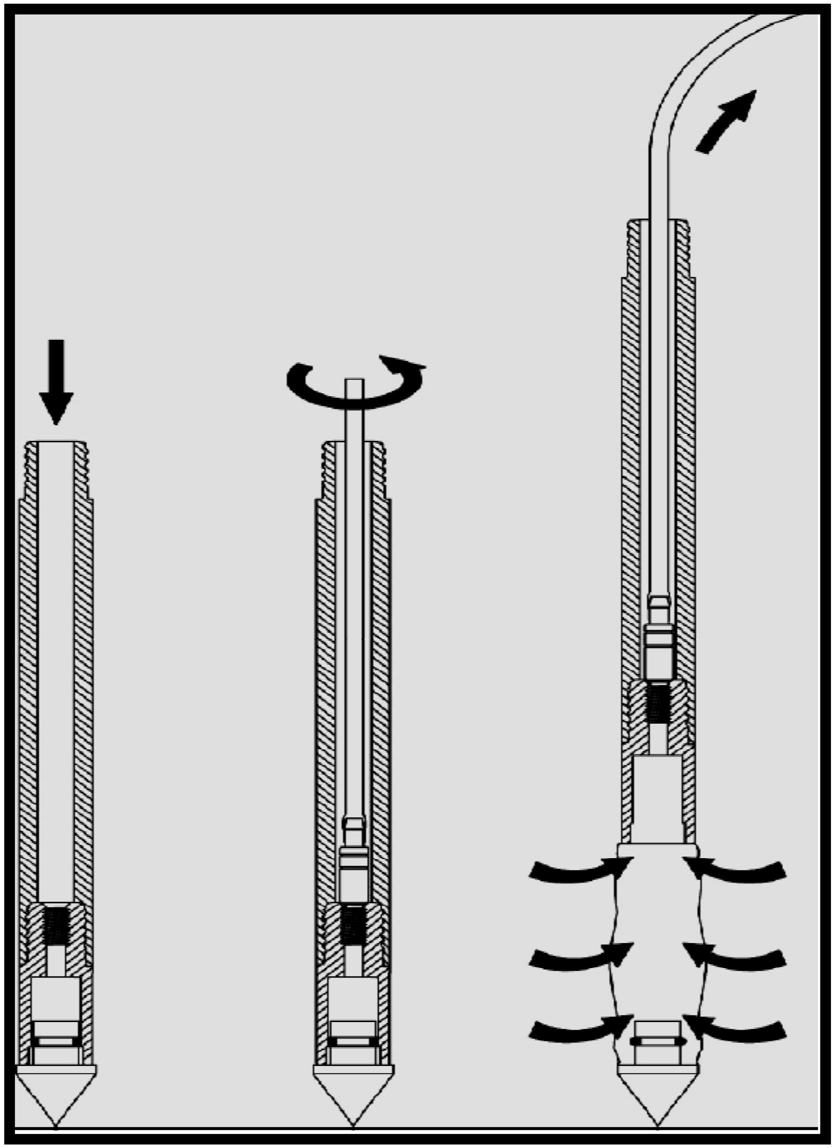
**Johnson et al., 1999**




**Layer One**
**Porosity = 40%**
**Vol Water = 15%**

**Layer Two**
**Porosity = 40%**
**Vol Water = 10%**

# POST RUN TUBING (PRT)

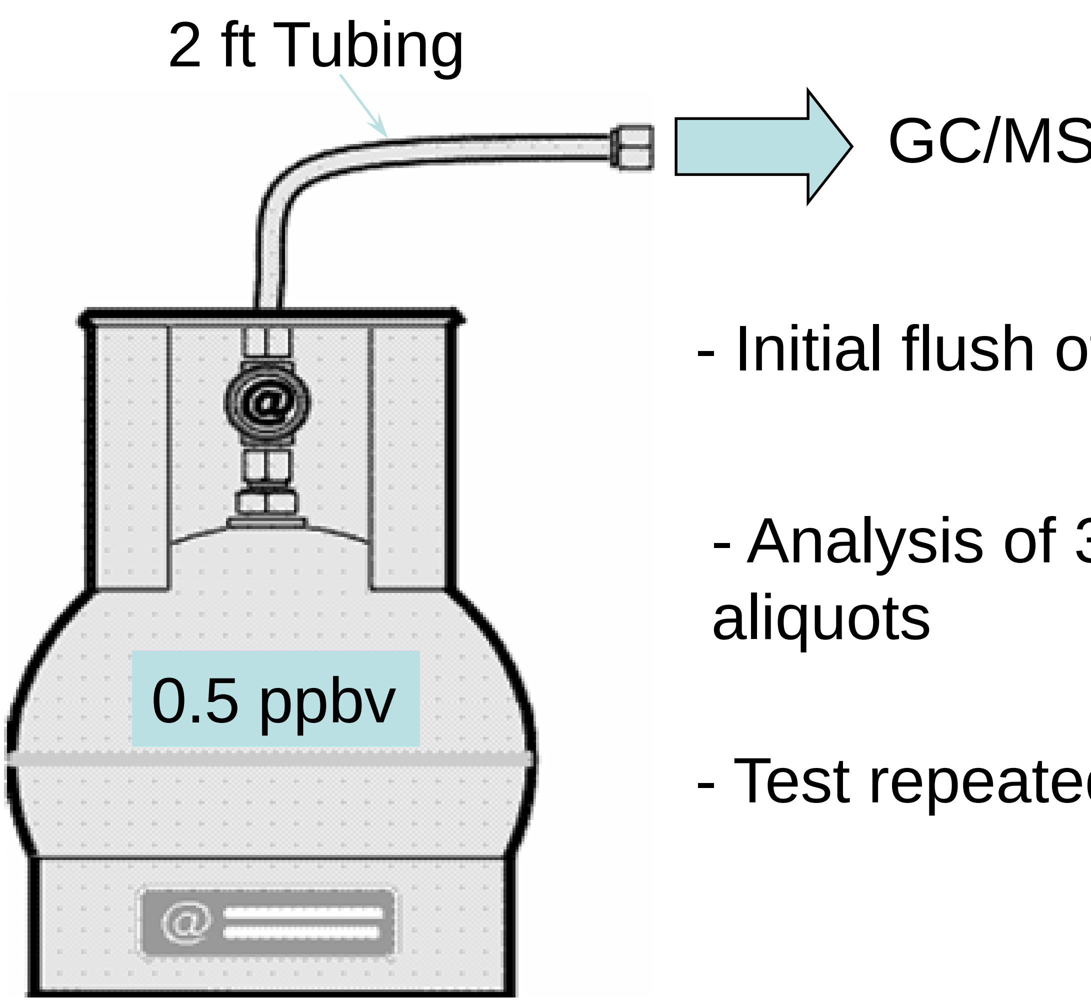


(McAlary, 2006)

(Hartman, 2007)

# TUBING REACTIVITY

**Hayes et al. (AWMA Conference 8/2006)**



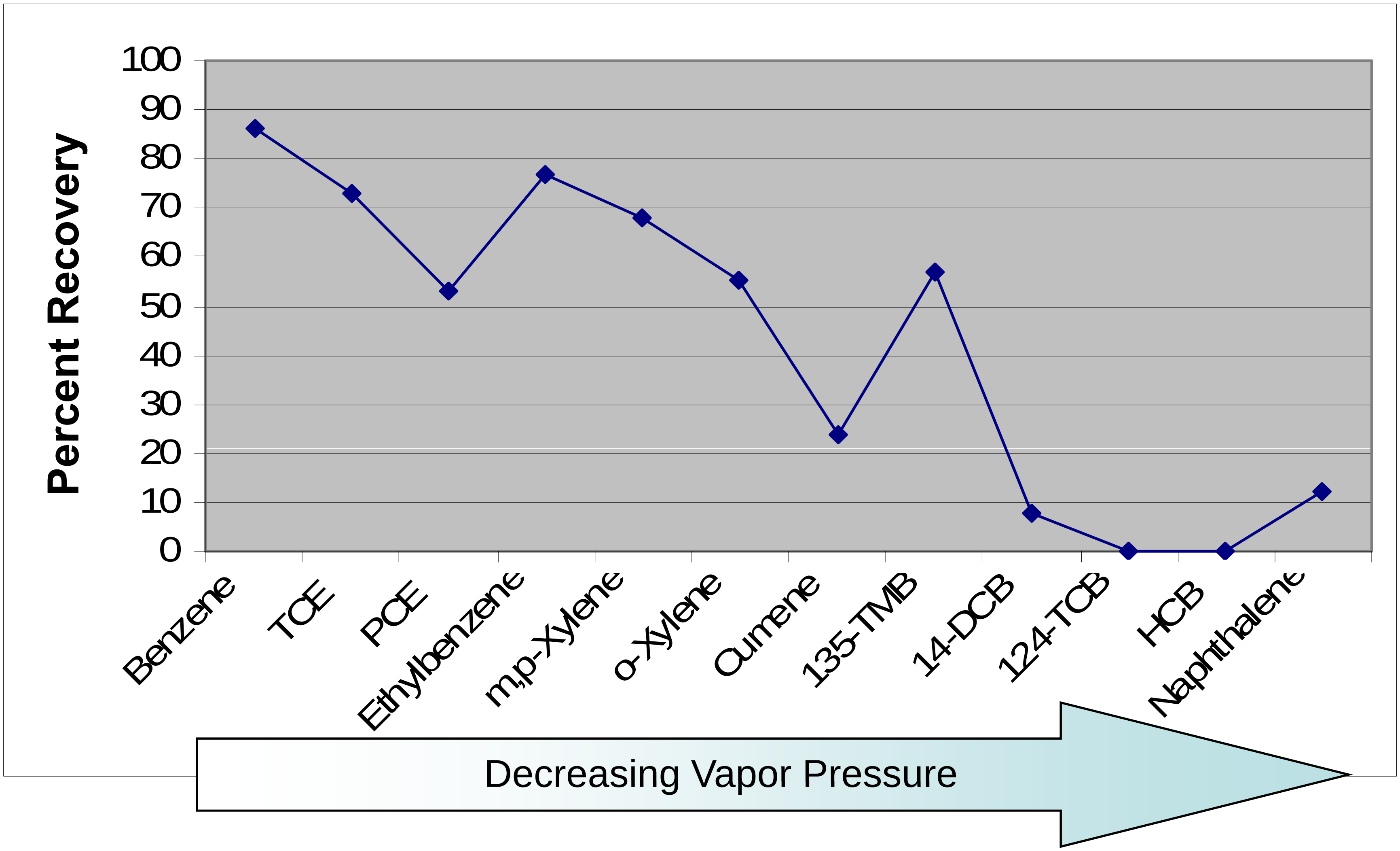

- Initial flush of 400 ml

- Analysis of 3 sequential aliquots

- Test repeated 3 times

# TUBING REACTIVITY

LD Polyethylene Tubing Recovery




**(Hayes, 2006)**

# TUBING REACTIVITY

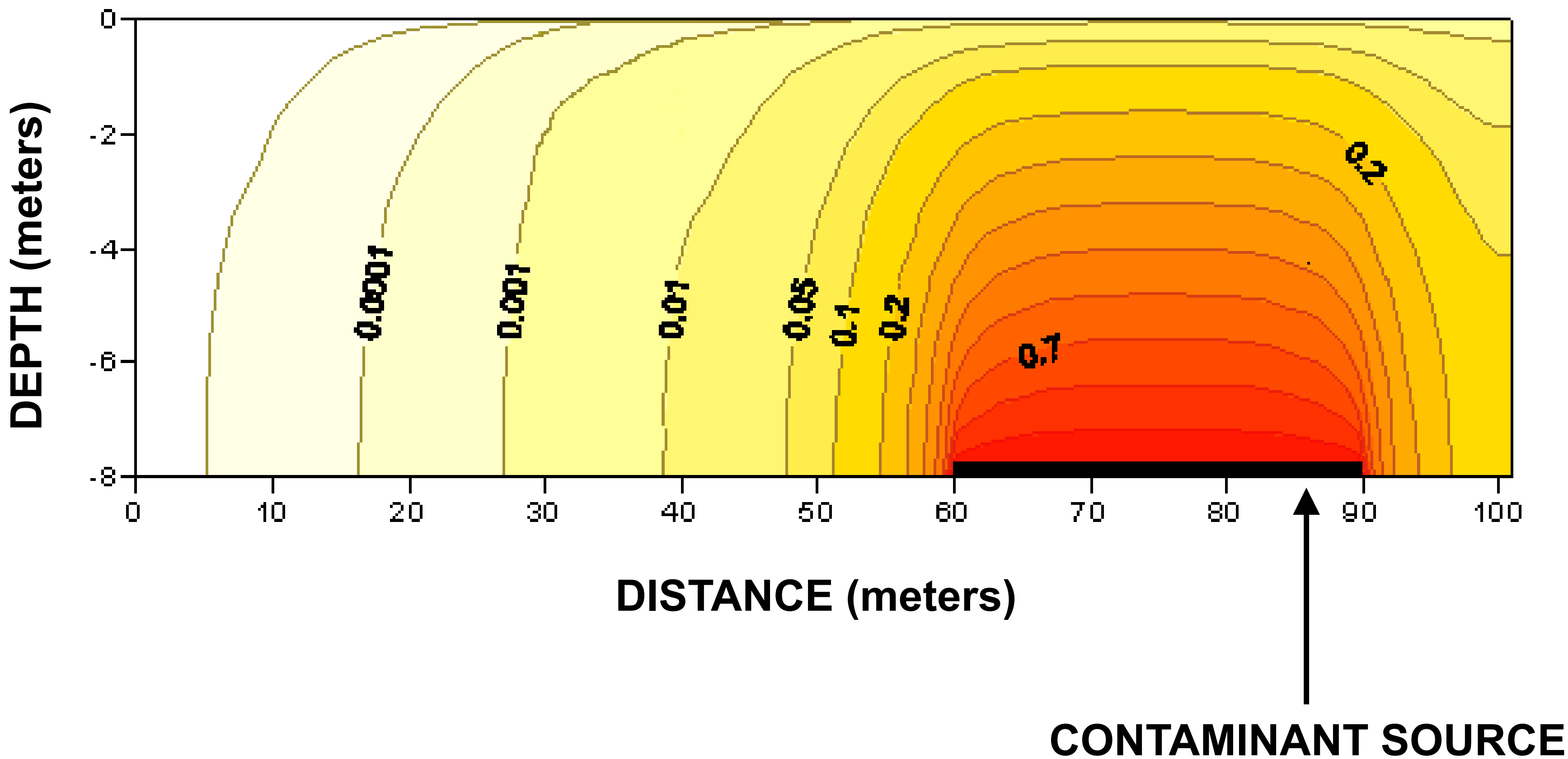
- **Nylaflow®**
  - **Low recovery for Naphthalene and 1,2,4-TCB**
- **PEEK**
  - **Acceptable**
- **Teflon®**
  - **Acceptable**
- **LD Polyethylene**
  - **Unacceptable for VOCs with low vapor pressures**

**(Hayes, 2006)**

# Soil Gas Modeling

## Theoretical Distribution of Soil Gas Above a Subsurface Contaminant Source

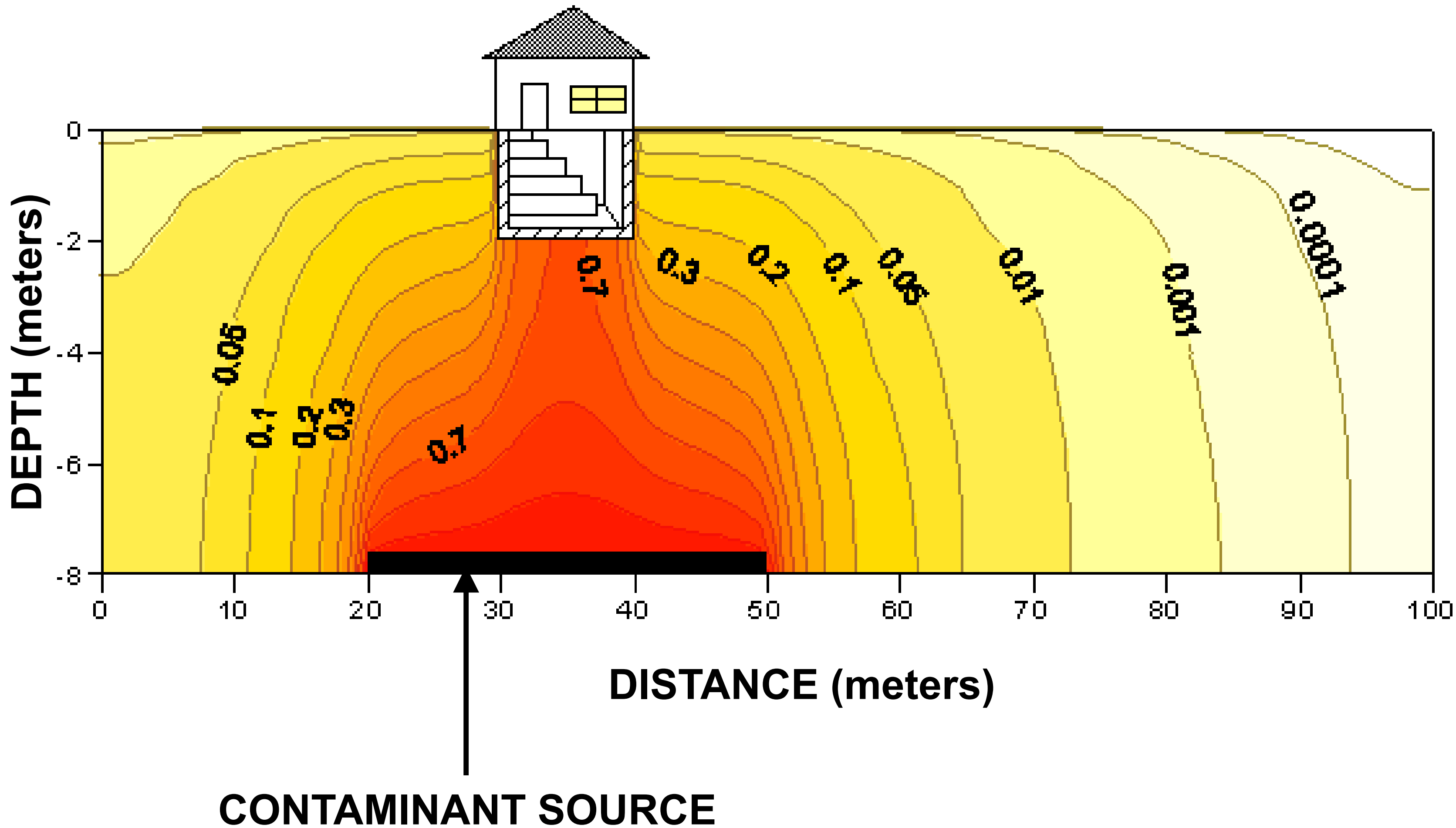
### Modified from Abreu et al. (AEHS Conference 3/2006)



# Soil Gas Modeling

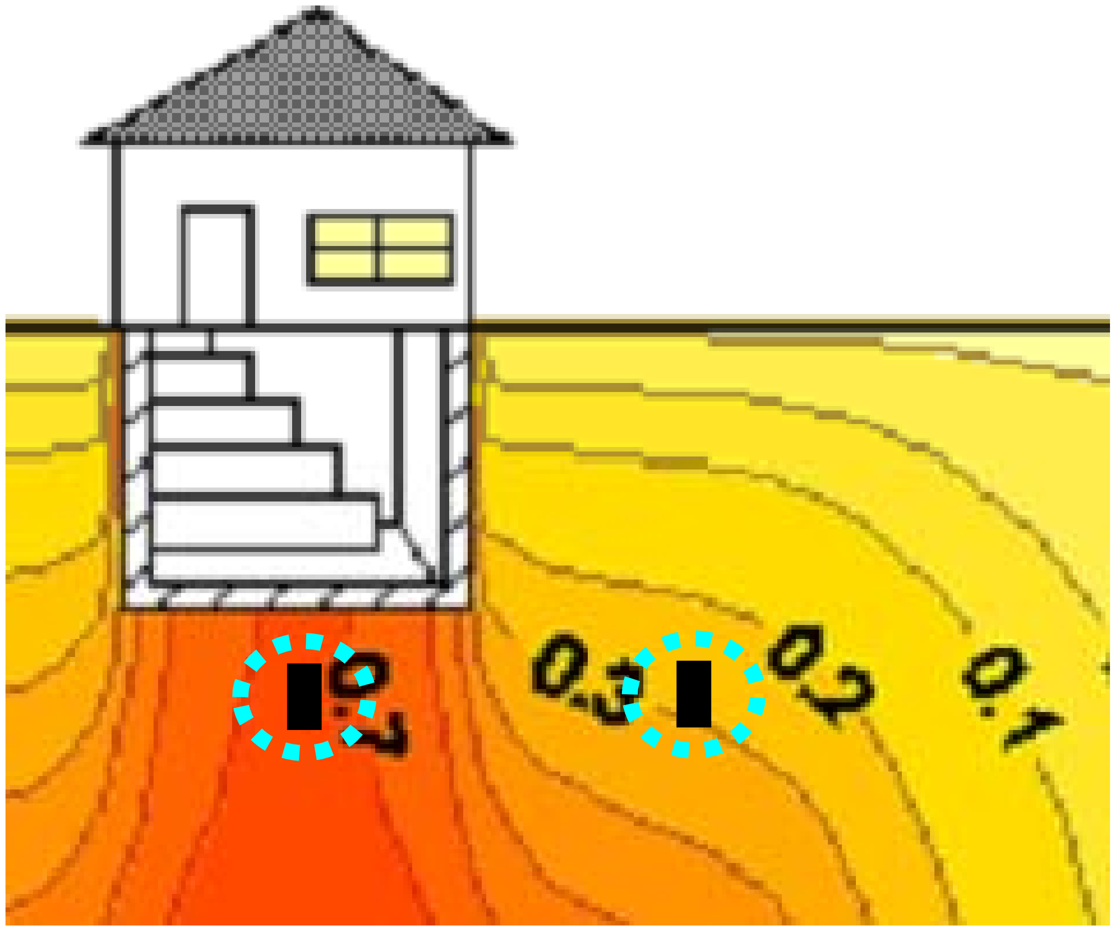
## Theoretical Distribution of Soil Gas Above a Subsurface Contaminant Source With a Building

**Modified from Abreu et al. (AEHS Conference 3/2006)**



# Soil Gas Sampling Depths

**Differences in "open-field" and "under-building" soil gas concentrations**



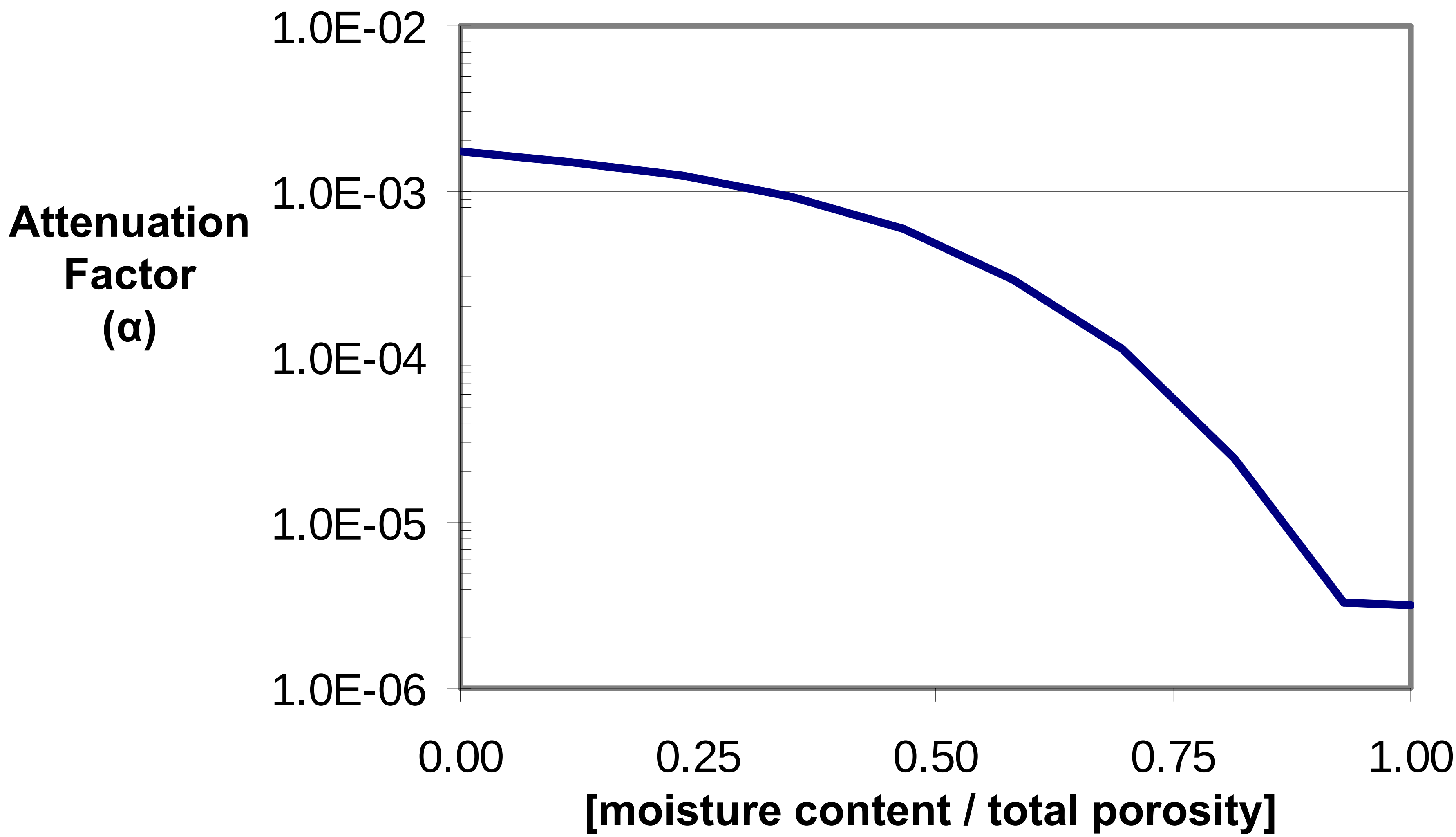

**Higher concentrations are observed under buildings**

# Johnson and Ettinger (1991) Modeling

- No preferential pathways in the vadose zone
- Steady-state conditions
- Vapor movement occurs through a porous medium (no bedrock)
- Model provides “order-of-magnitude” estimate with good quality site-specific data (Hers et al., 2003, GWMR, v. 23, n. 2, p.119 – 133)

# Sensitivity of Input Parameter

**Volumetric Moisture Content of the Soil**
**(porosity of 43% assumed)**

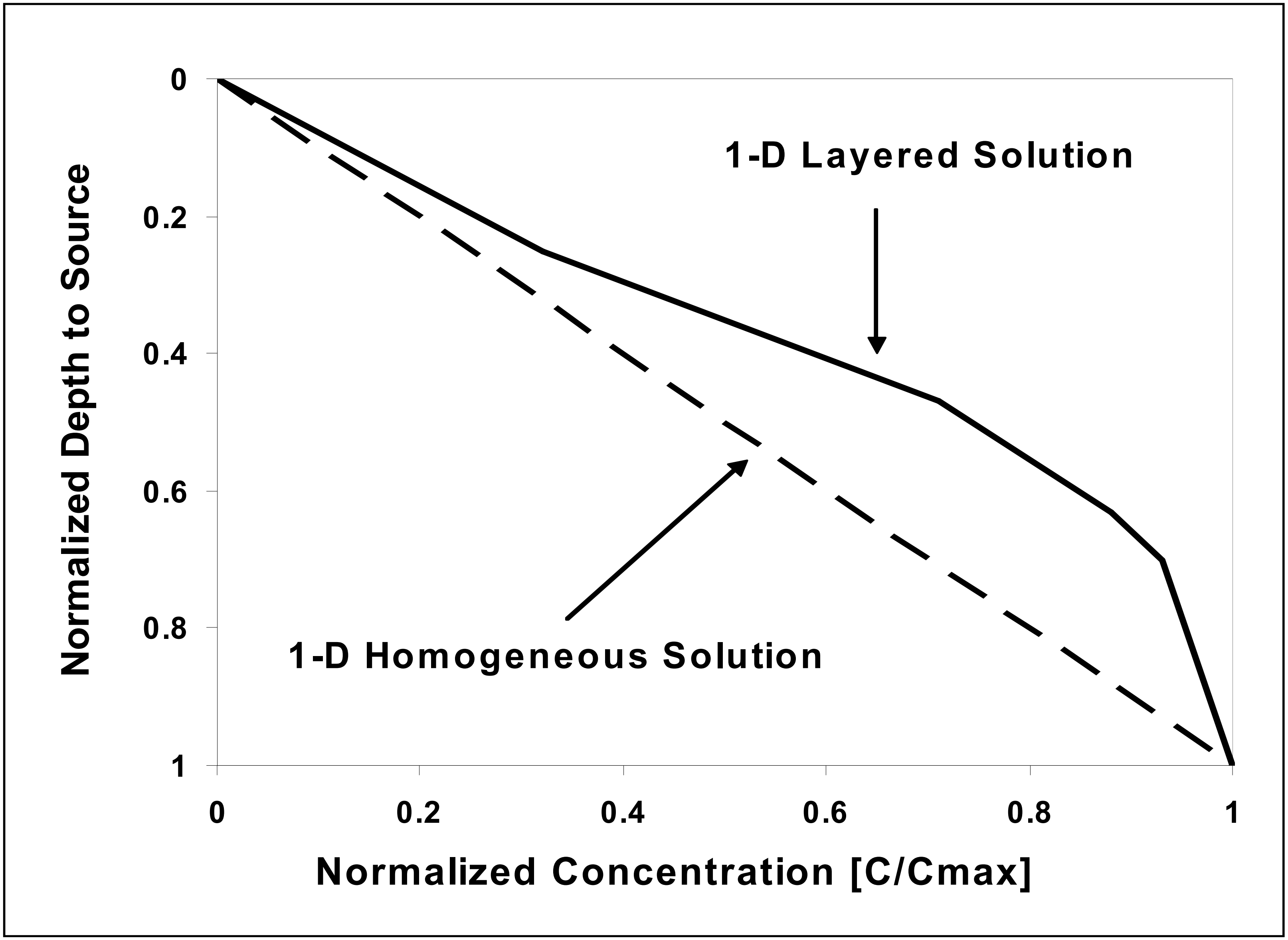


# DTSC Approach to Petroleum
## Johnson et al., 1999

### Documentation of Biodegradation in the Field

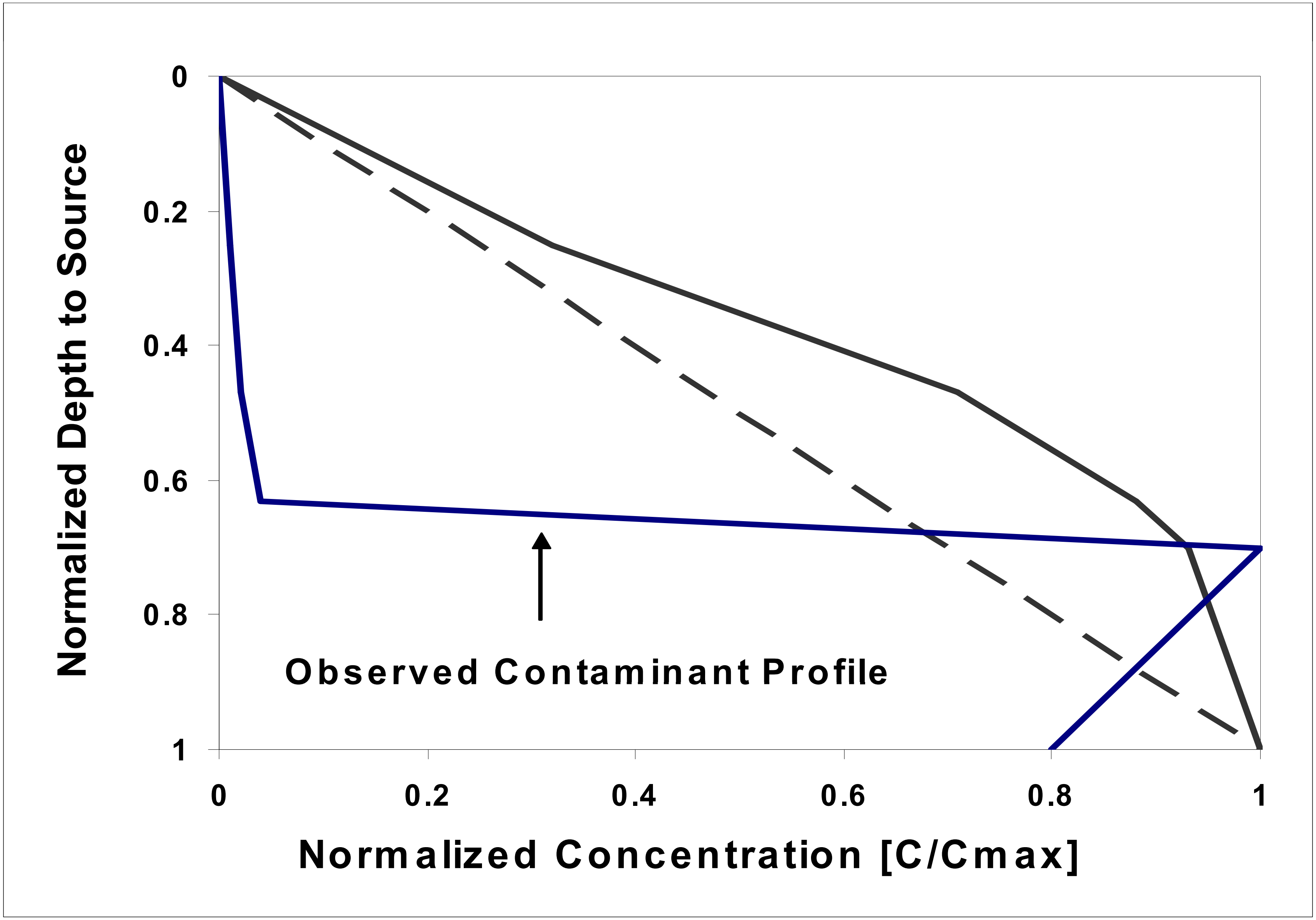
- Collect contaminant, oxygen, and carbon dioxide data with depth
- Develop site conceptual model (layer thickness, porosity, moisture, and depth to source)
- Calculate the ‘expected’ or ‘theoretical’ contaminant profile

# Expected or Theoretical Contaminant Profile



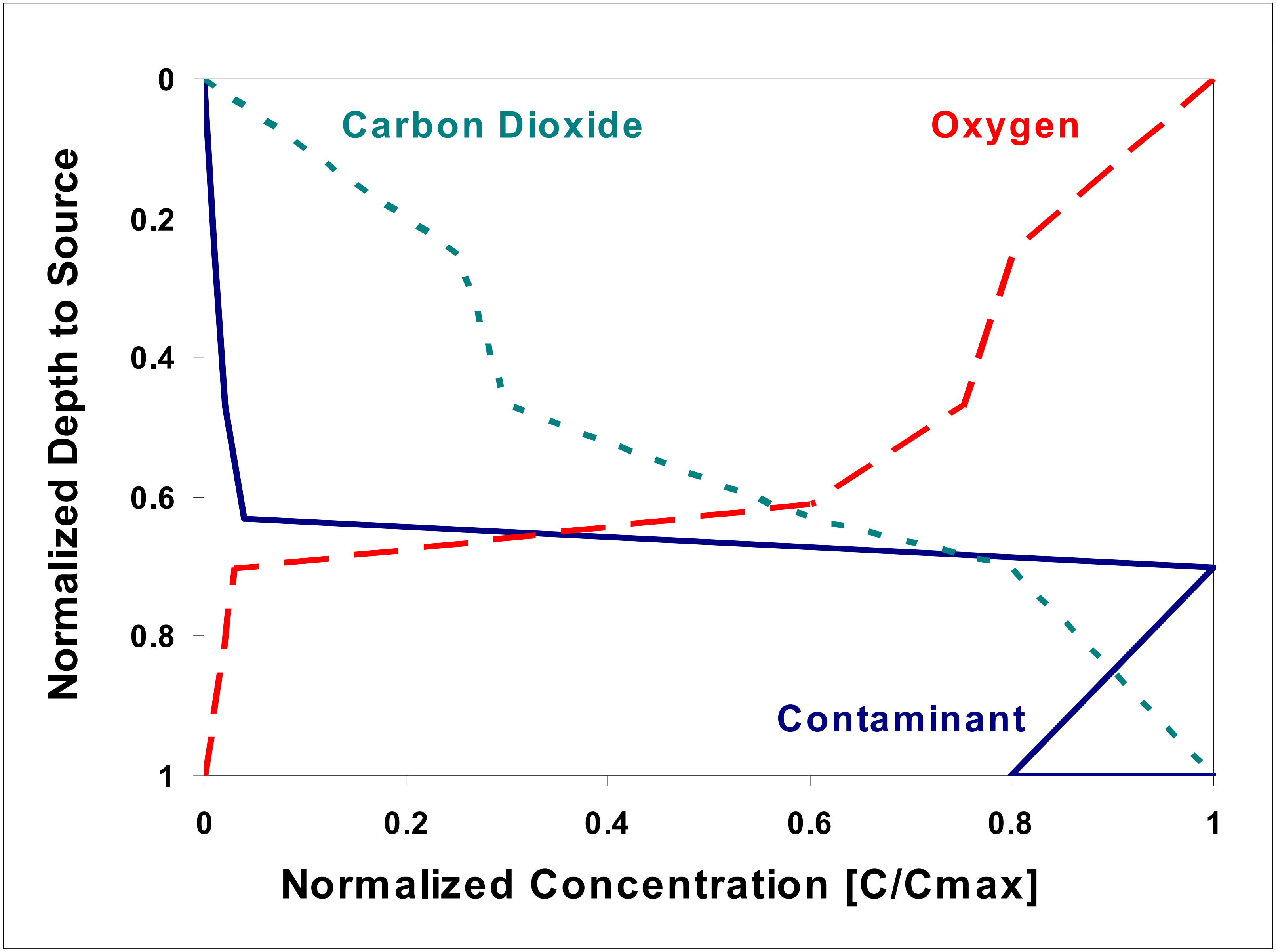

Taken from Johnson et al., 1999

# Observed Contaminant Profile




Taken from Johnson et al., 1999

# Evidence of Biodegradation




Taken from Johnson et al., 1999

# DTSC Approach to Petroleum
## Johnson et al., 1999

**Verification of Biodegradation Occurrence**

- Soil gas profiles are consistent
- Soil gas monitoring indicates stable subsurface profiles

Hence, a “dominant layer” exists in the subsurface where significant biodegradation occurs