# TCE - a new environmental problem?


*Presented by Mark Chapman*

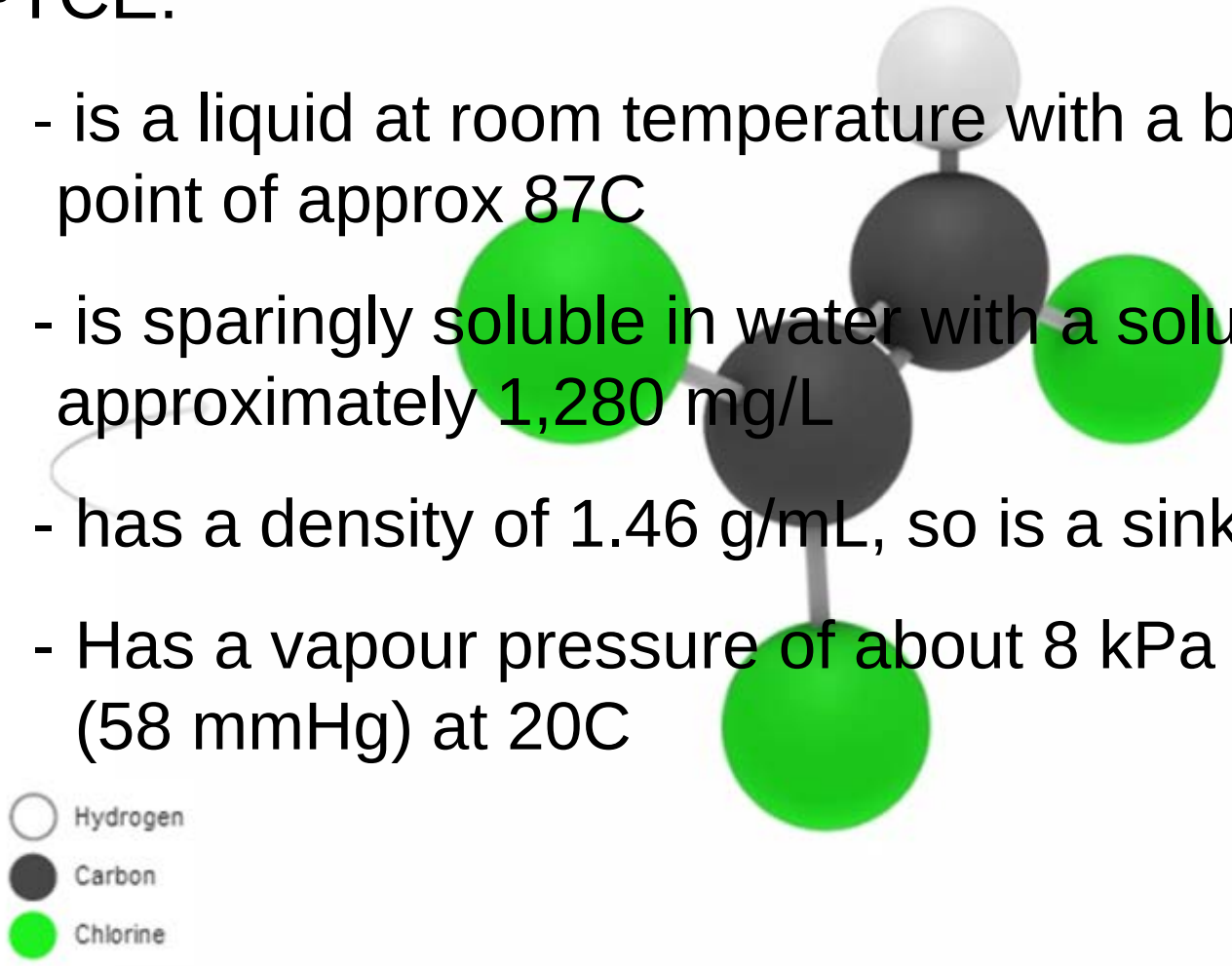
*URS Senior Principal Risk Assessor*

# What is TCE?

- Trichloroethylene, trichloroethene or TCE is an industrial volatile chemical
- First widely produced in the 1920s, production and use increased until the 1970s
- Widely used for metal degreasing in manufacturing including vapour degreasing
- Also used for decaffeinating coffee, dry cleaning and anaesthetic for surgery and inhalation analgesic in childbirth until about 1960
- Reduced usage and no longer manufactured in Australia, but use has not been discontinued

# Phys-Chem Properties

- TCE:
  - is a liquid at room temperature with a boiling point of approx 87C
  - is sparingly soluble in water with a solubility of approximately 1,280 mg/L
  - has a density of 1.46 g/mL, so is a sinker
  - Has a vapour pressure of about 8 kPa (58 mmHg) at 20C



# TCE Contamination in the news

ADVERTISER.COM.AU

## toxic zone evacuation call

### Worried residents still want answers

SAM HEATON
POLICE REPORTER

TOXIC AREA: For left, the contaminated zone in Clovelly Park; left, resident Brian Allen; above, Ash Ave, which residents have been told to evacuate; below, the local playground. Pictures: SAM WUNDKE

### WHAT IS TRICHLOROETHYLENE?

### Reactions to chemicals were evident for years

FEARS: Sisters Melita Bedrall and Jo Heatley lived in Clovelly Park as kids and now have unexplained health issues.

## Clovelly Park carcinogen danger forces residents to move house

Updated 3 Jul 2014, 2:37pm

**Some residents in an Adelaide southern suburb are being told to relocate after a carcinogen was detected in air, soil and groundwater.**

Clovelly Park residents have known of toxic contamination in the area for years but thought they were safe in their houses.

But now the South Australian Government has told residents from close to 30 properties they should move out and Environment Minister Ian Hunter is not ruling out the demolition of some houses.

"It may well be that those homes will be demolished and new ones will be built with new mechanisms with impermeable membranes [and] concrete slabs, but that's for down the track," he said.

PHOTO: Playground: Solvent vapours are a risk in air, soil and groundwater.

MAP: Clovelly Park 5042

**TCE contamination in the Clovelly Park area made the media (newspaper, radio and/or TV), every day for more than 40 days straight in mid-2014**

# EPA Site Contamination Branch - Focus on TCE Sites

## Current

EPA assessment areas

- Southeastern Edwardstown
- Beverley, Woodville West, Woodville South, Findon and Allenby Gardens
- Clovelly Park-Mitchell Park new
- Glenelg East
- Hendon industrial area
- 1102 South Road, Edwardstown
- Southern Edwardstown
- Edwardstown–South Plympton

# Why is TCE now a problem?

## Handling and disposal

- High rate of production and use through most of the 20th century
- Currently thousands of sites identified across North America, Europe, Australasia as potential DNAPL sites
- Safe disposal often not practiced/regulated until the 1980's
- Common practice to dispose of waste solvent to a (well ventilated) dumping area and allow the solvent to evaporate
- MSDS advice from 1948
  - *"Waste tricholoroethylene is flammable and generally can be burned in a furnace or spread on waste and burned on a burning ground….."*
  - *"Bury away from water supply or allow solvent to evaporate to atmosphere"*

# Why is TCE now a problem?

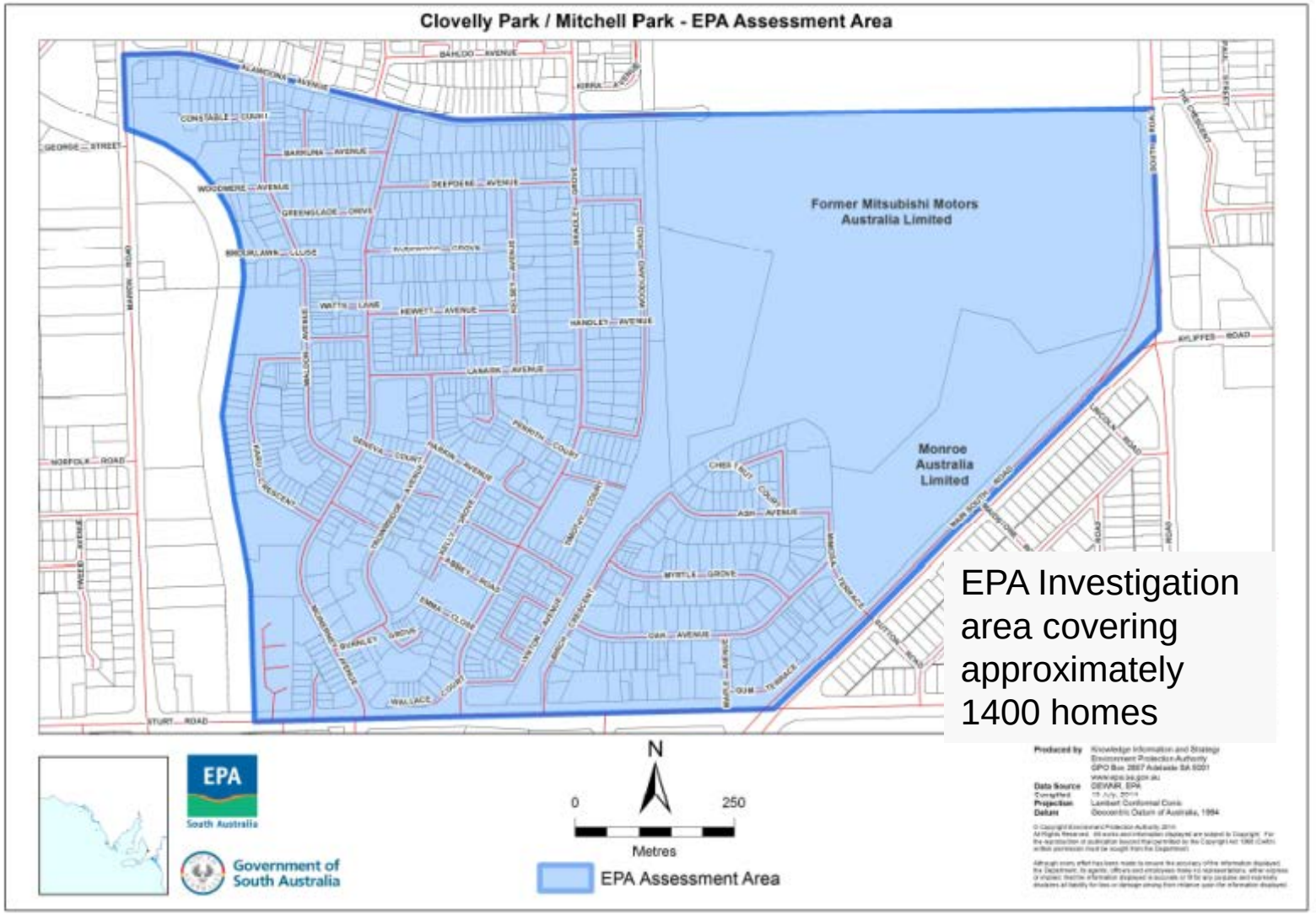
## 10-Fold Toxicity Data Changes in 2011-2012

- There are no Australian groundwater or ambient air guidelines for TCE
- Until about 2012, reference was generally made to the World Health Organisation toxicity data for inhalation (23 µg/m$^3$ for ambient air based on cancer risk)
- In September 2011 the US EPA released their updated TCE toxicity assessment. 2 µg/m$^3$ for ambient air
- This US Guideline was adopted in the ASC NEPM in the derivation of soil vapour Health Investigation Levels 20 µg/m$^3$ for soil vapour

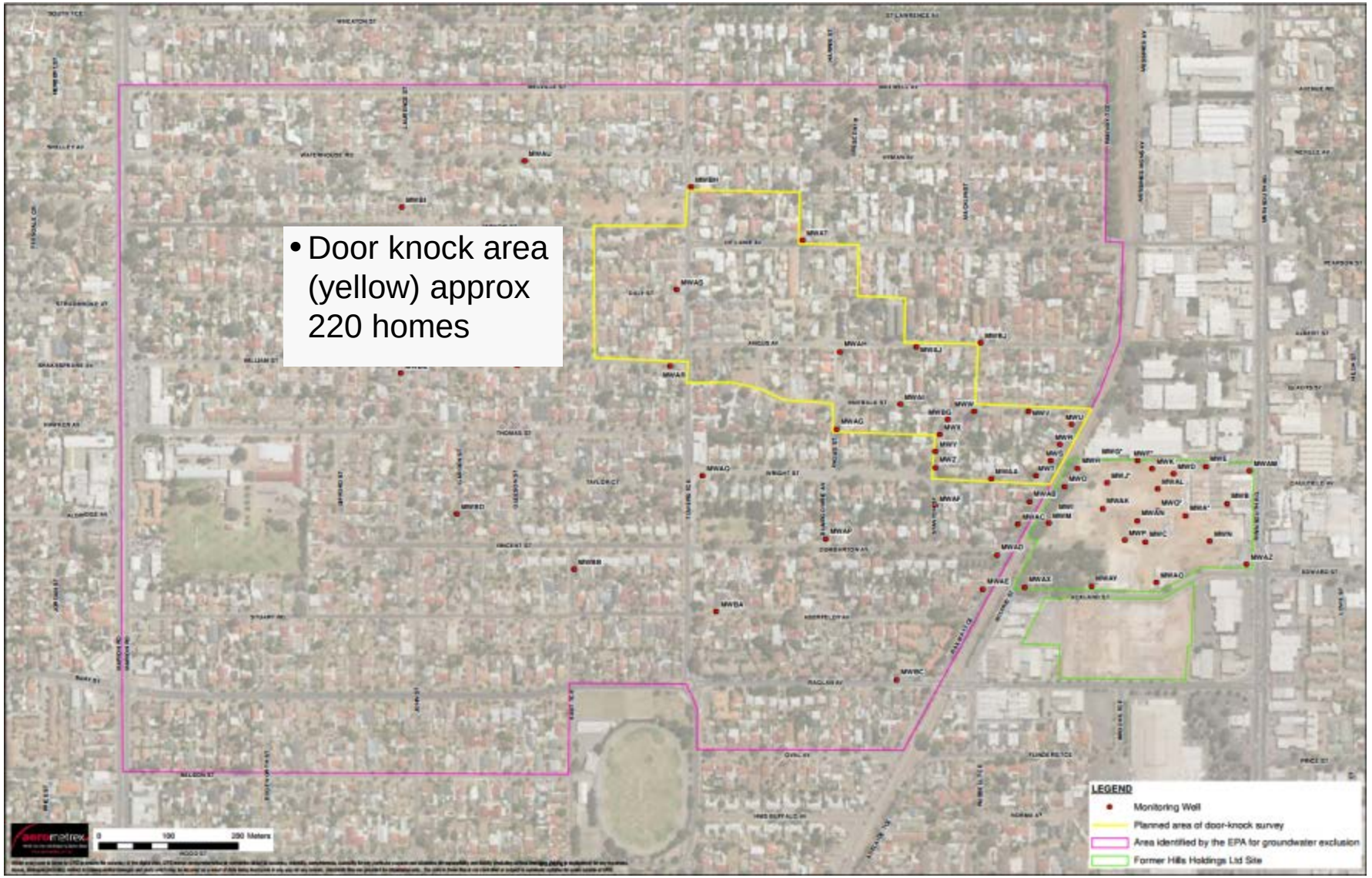
## Stability/longevity in the subsurface environment

- In aerobic environments PCE and TCE are not prone to biodegradation

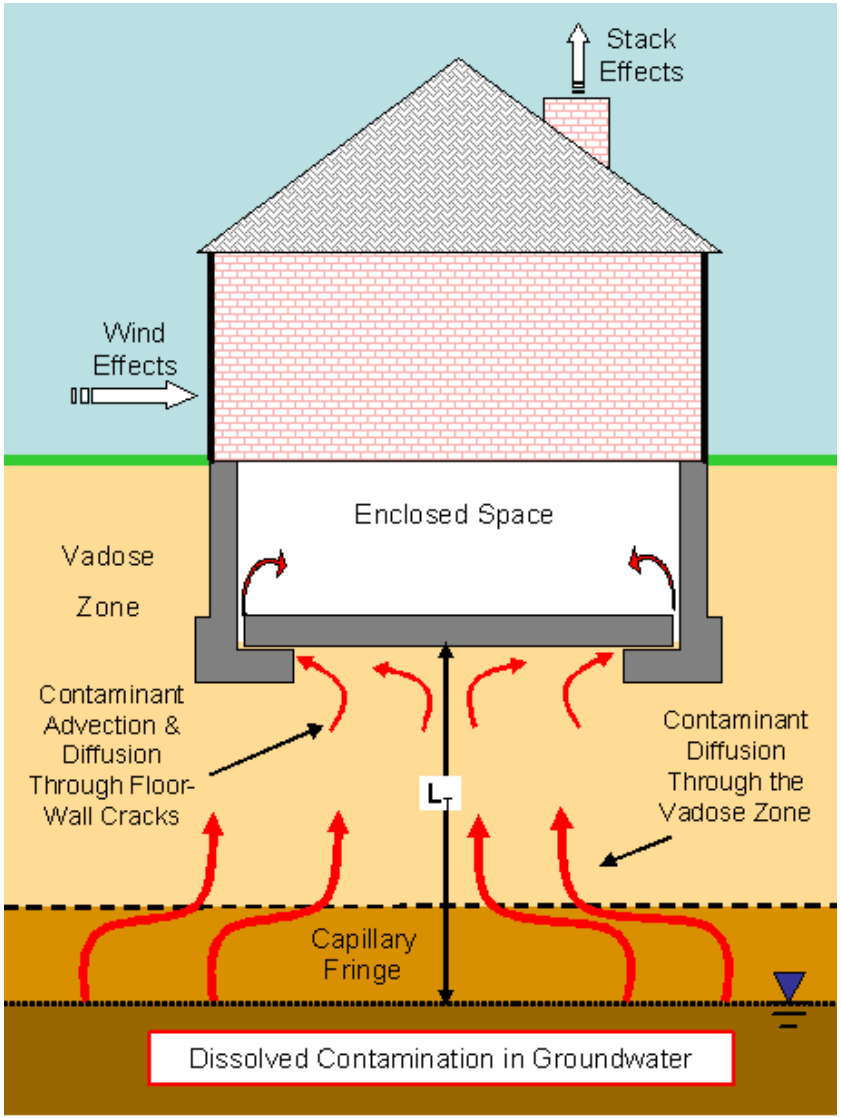
# Mitchell Park – Clovelly Park Investigation Area

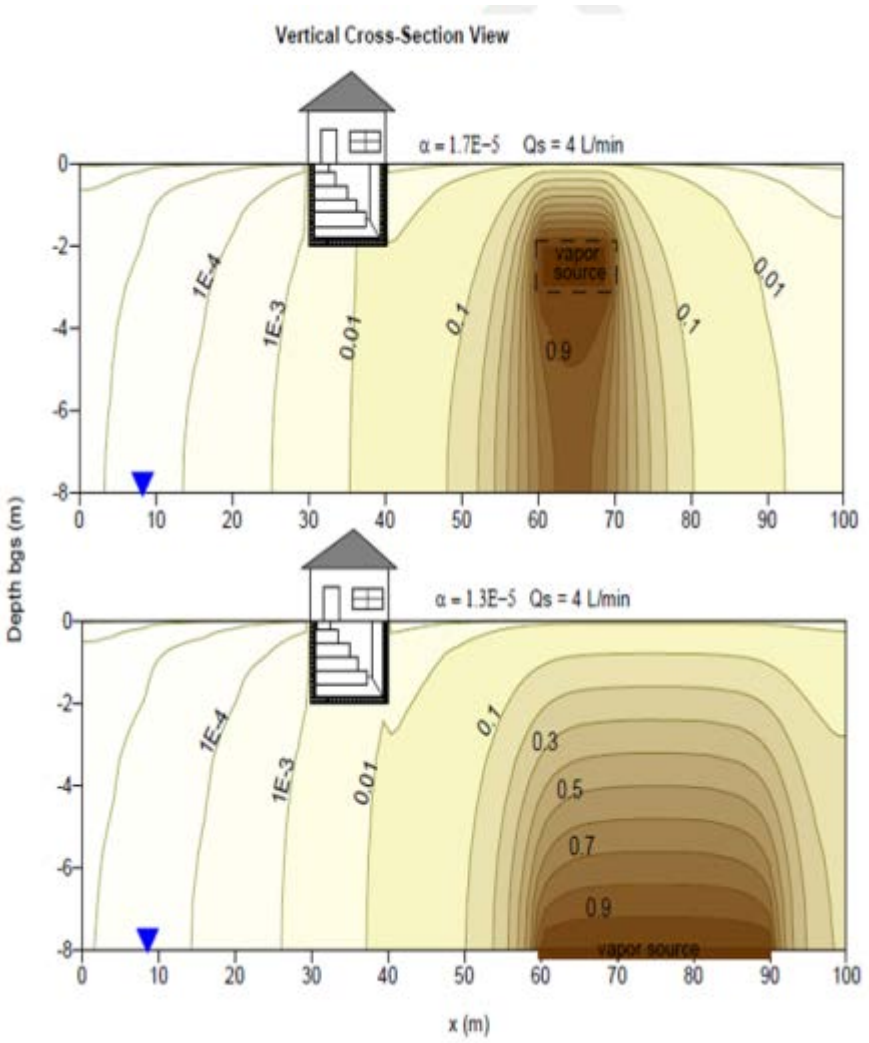


# Edwardstown PCE/TCE Off-Site Investigation



# Conceptual Model Vapour Intrusion



# Conceptual Model for DNAPL in Subsurface (UK Env Agency)

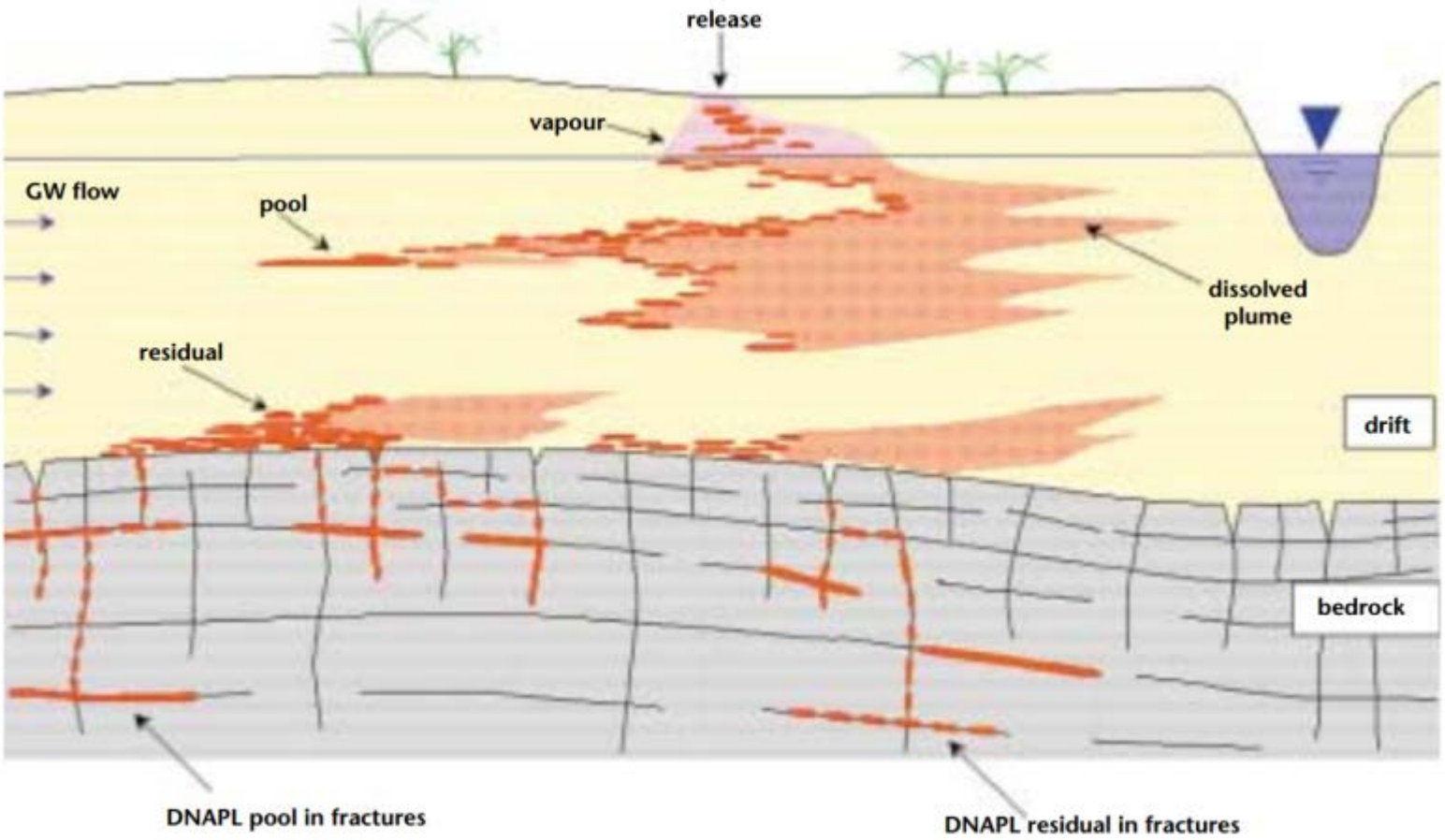



**Figure 2** | DNAPL distribution in unconsolidated deposits (after Pankow and Cherry, 1996)

# Heterogeneous Distribution in the Subsurface

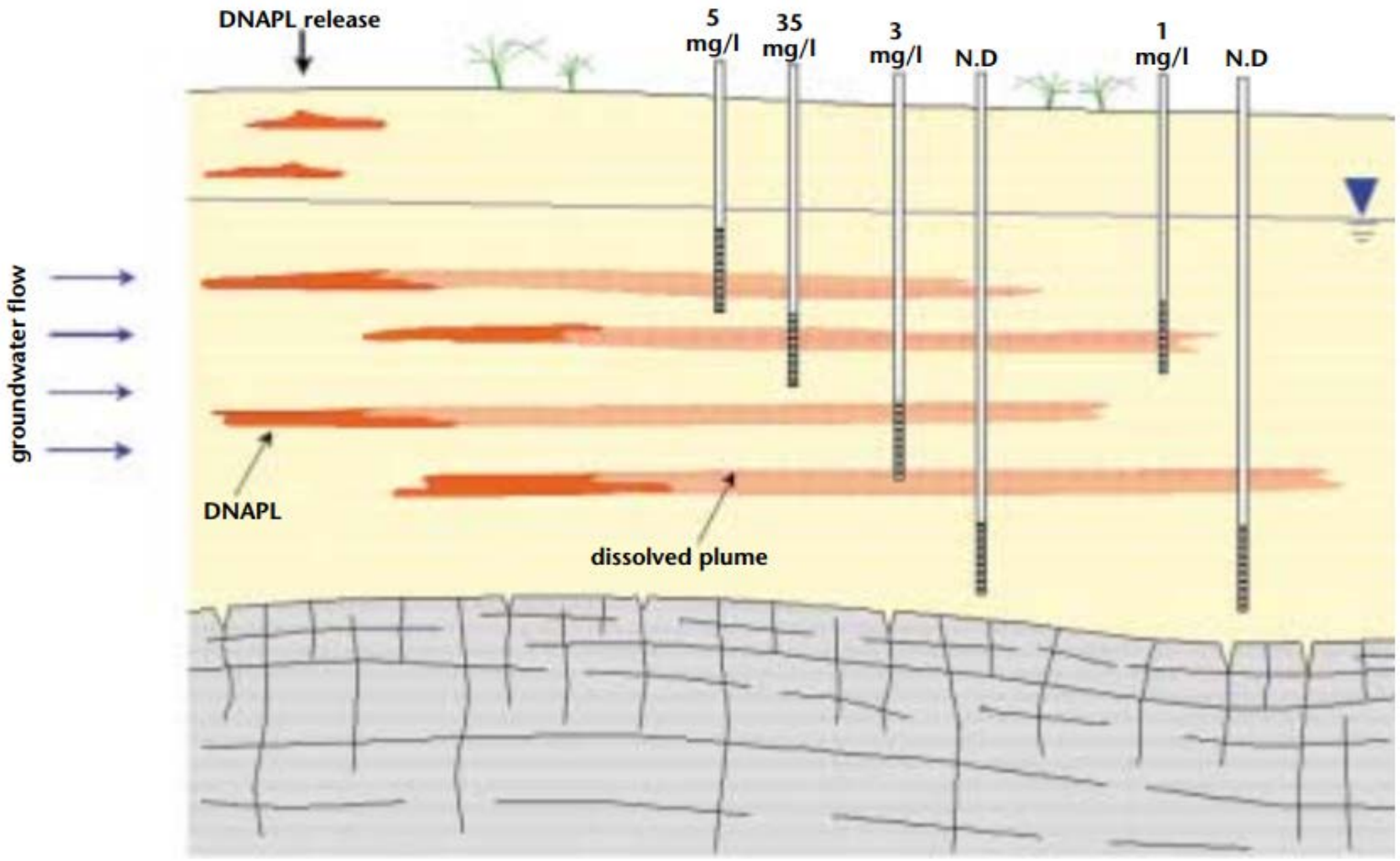



**Figure 6a** | Cross-section depicting spatial variability of groundwater concentrations in a plume

# Solute concentration at the water table

From a vapour perspective, we are interested in concentrations at the top of the water table

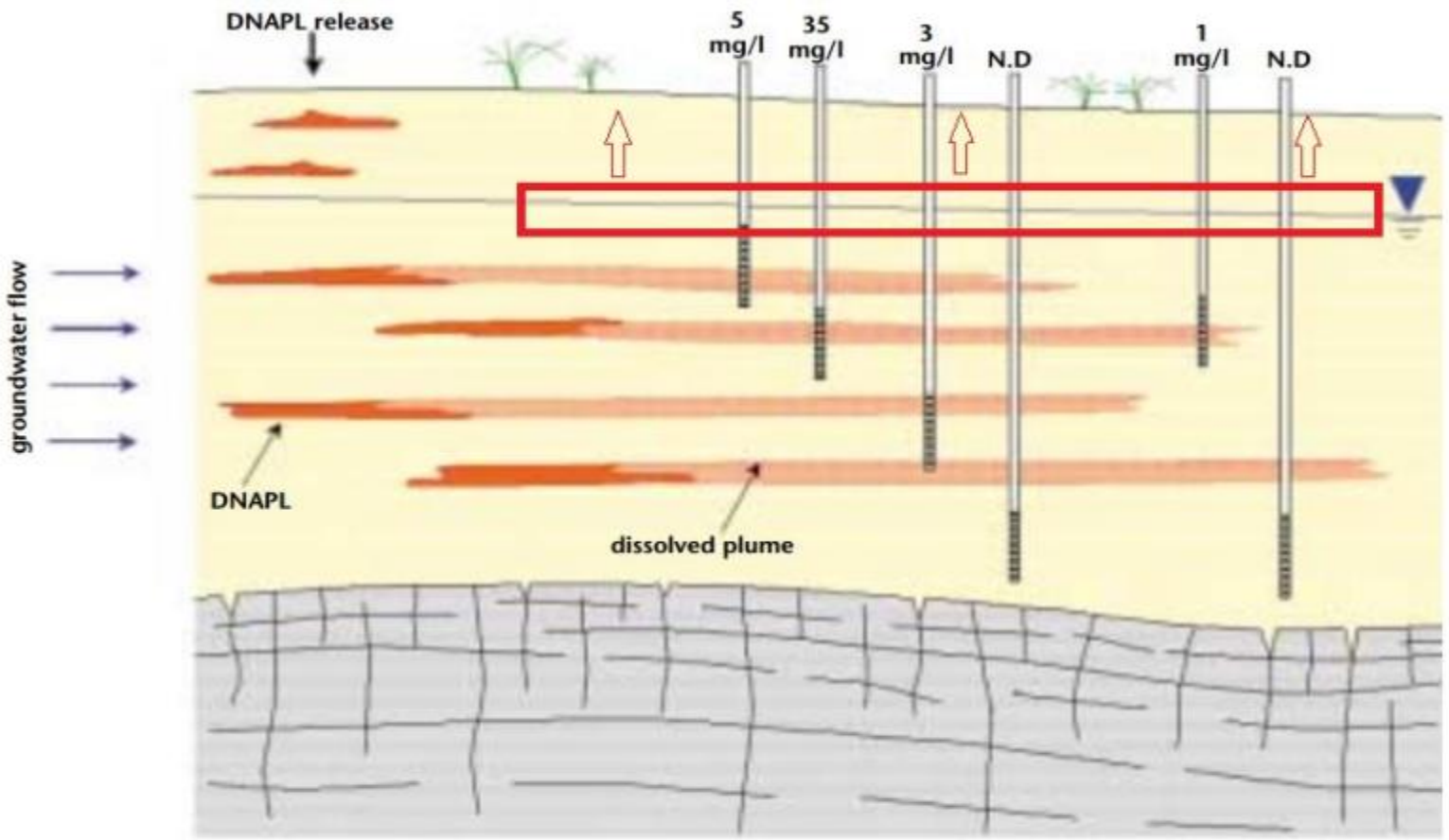


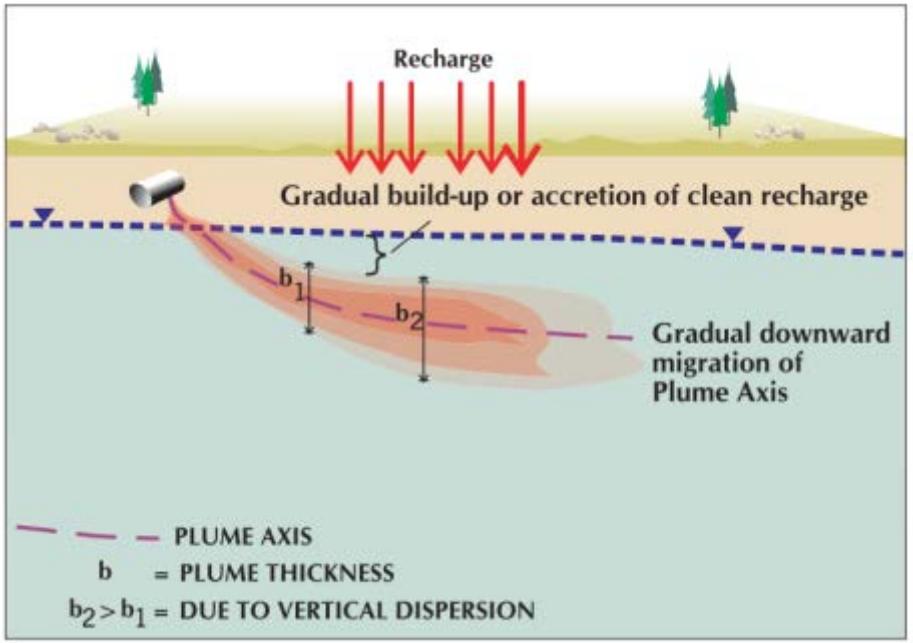

**Figure 6a** | Cross-section depicting spatial variability of groundwater concentrations in a plume

# Plume Diving – Resulting in reduced vapour concentrations

- $Di_{air}$ = 7x10$^{-2}$ cm$^2$/s
- $Di_{water}$ = 1x10$^{-5}$ cm$^2$/s

- TCE diffusion rate in air is approximately 4 orders of magnitude greater than in water.

- Plume diving The gradual vertical migration of the solute plume within the aquifer

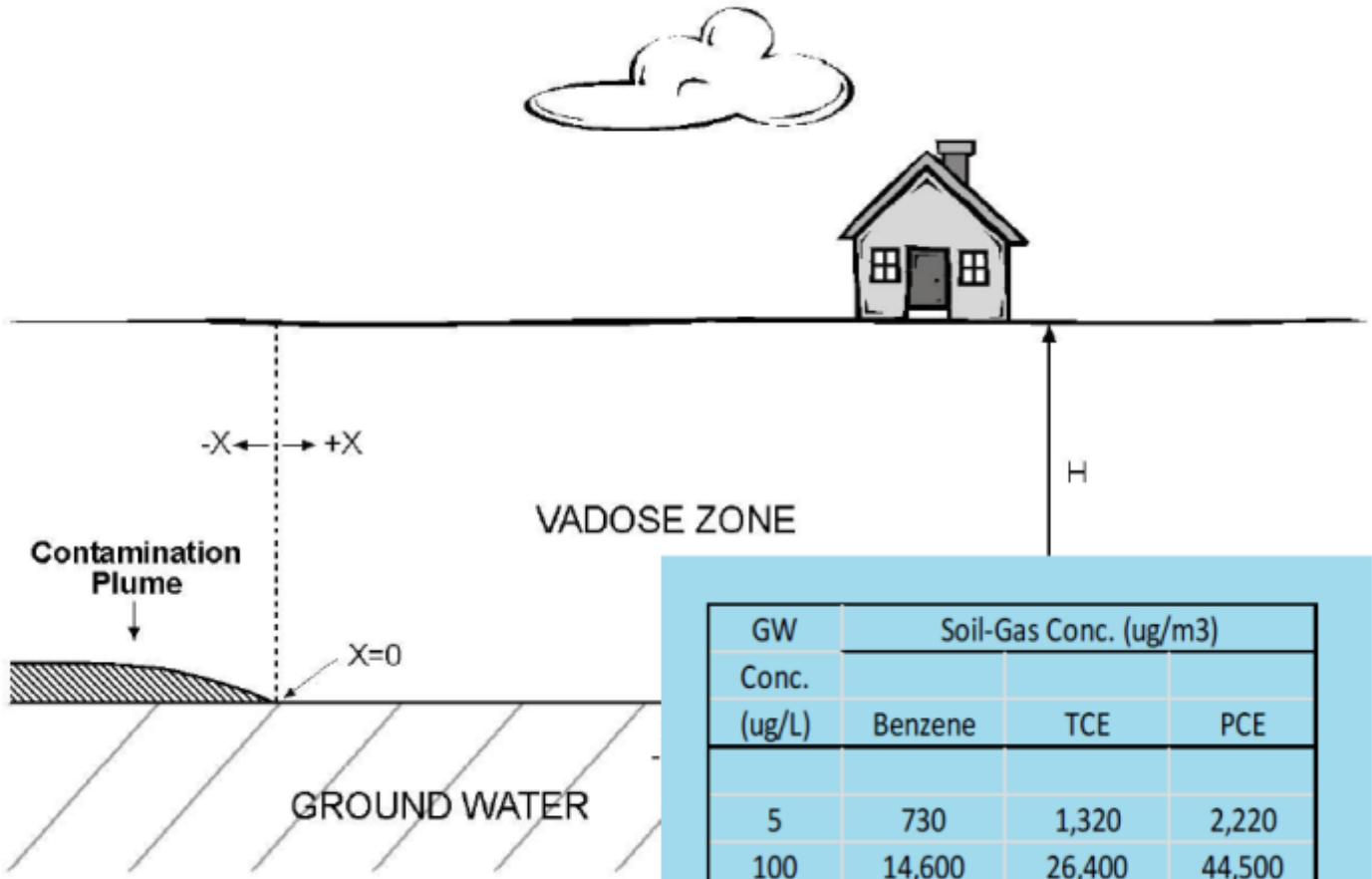



**Several reasons why vapour concentrations may be lower than Henry's predictions**

1. Depletion of solute concentrations at the water table interface due to relative diffusion rates
2. Fresh water recharge creating a fresh water "lens"
3. Potential for "flushing" of the solvent from soil vapour as water infiltrates after heavy rainfall

# Henry's Law Predictions for Groundwater

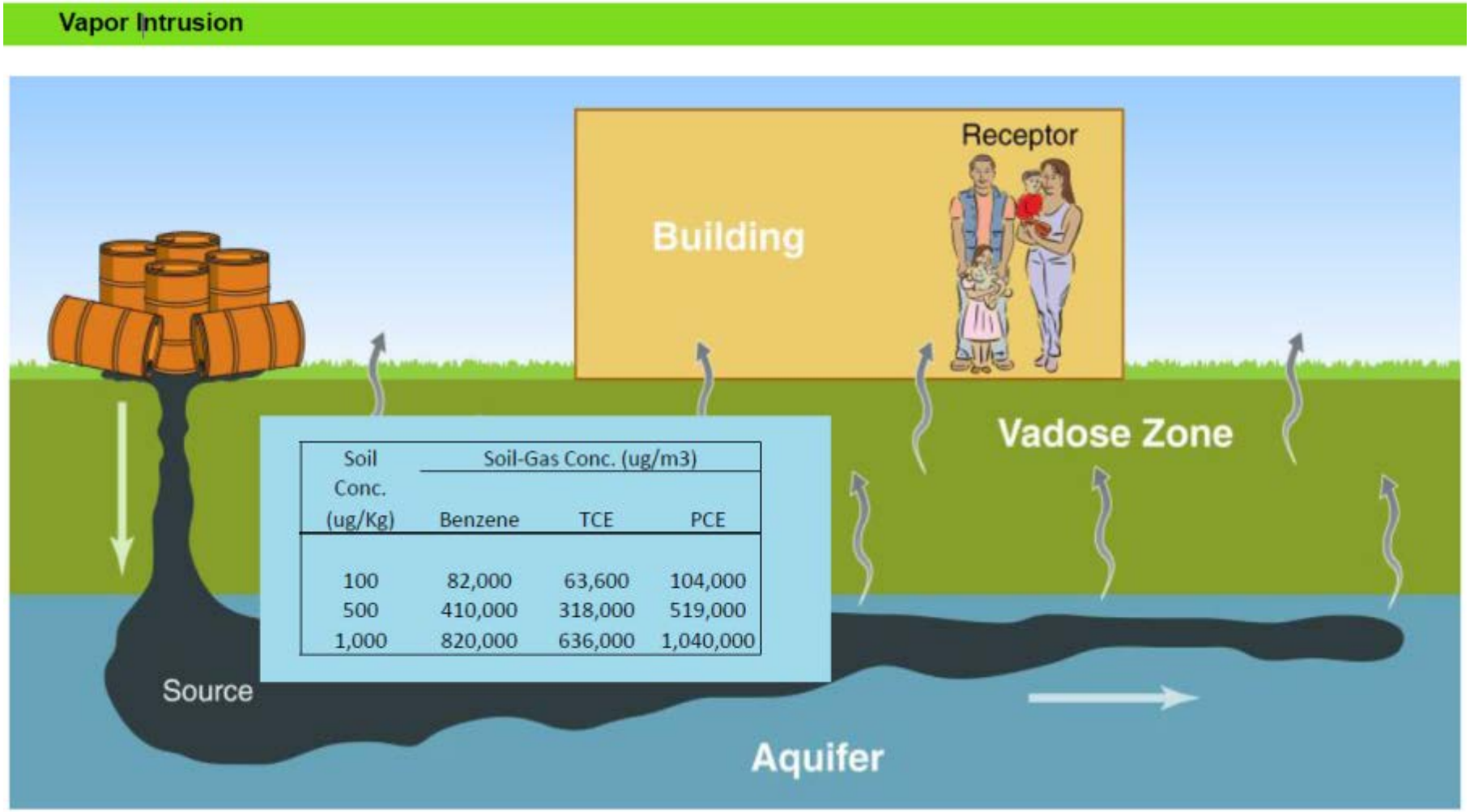
**Vapor Intrusion**




| GW Conc. (ug/L) | Soil-Gas Conc. (ug/m3) | | |
|---|---|---|---|
| | Benzene | TCE | PCE |
| 5 | 730 | 1,320 | 2,220 |
| 100 | 14,600 | 26,400 | 44,500 |
| 1,000 | 146,000 | 264,000 | 445,000 |

NEPM Soil Vapour HIL for TCE is **20 µg/m³**

# Henry's Law Predictions for Soil




| Soil Conc. (ug/Kg) | Soil-Gas Conc. (ug/m3) | | |
|---|---|---|---|
| | Benzene | TCE | PCE |
| 100 | 82,000 | 63,600 | 104,000 |
| 500 | 410,000 | 318,000 | 519,000 |
| 1,000 | 820,000 | 636,000 | 1,040,000 |

NEPM Soil Vapour HIL for TCE is **20 µg/m$^3$**.

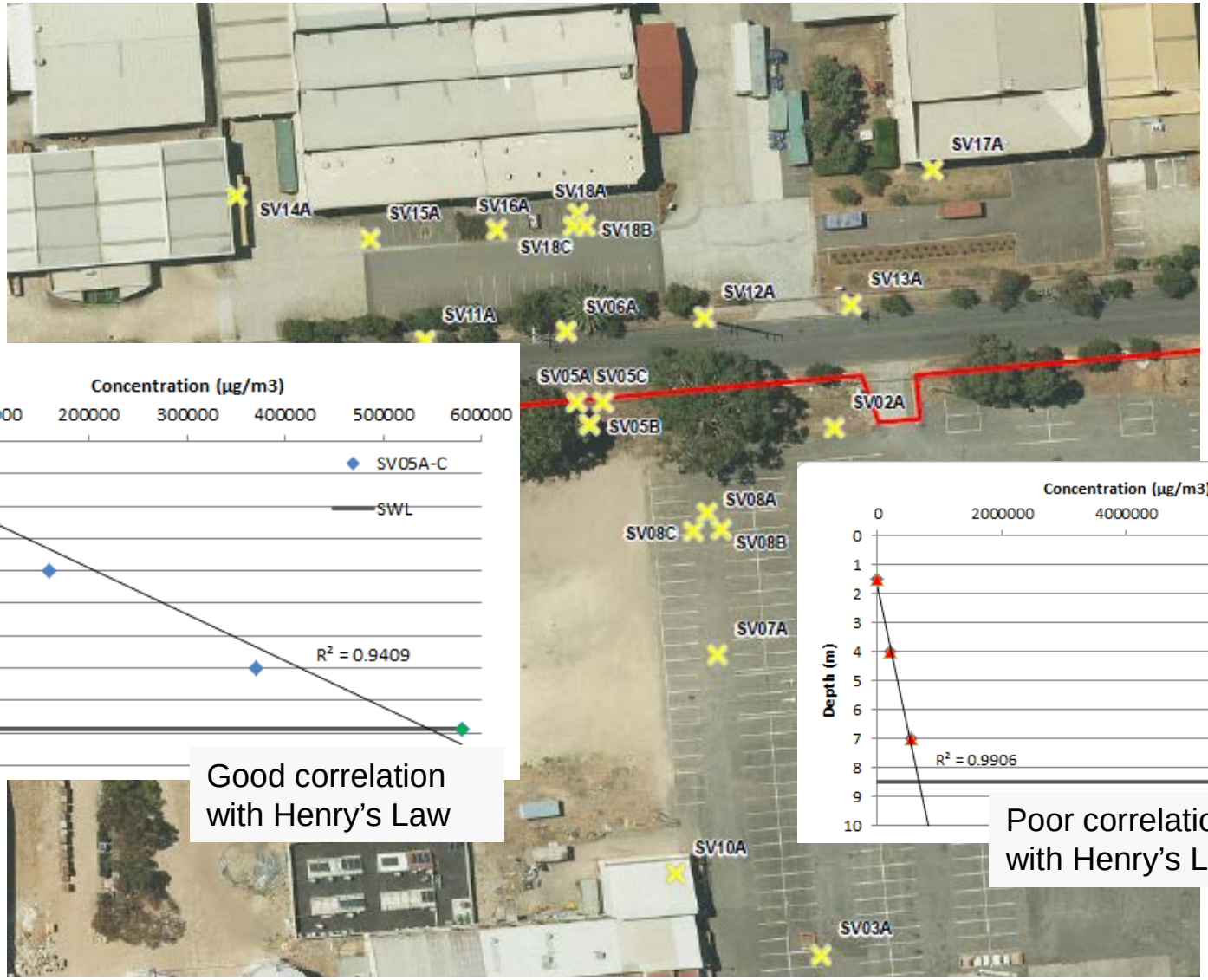
Need soil vapour data to assess soil sources in particular

# How to Assess Exposure Concentrations and Risk

1. Identify area of concern, then what:
    2. Modelling transport from subsurface source concentrations (groundwater or soil vapour)
    3. Application of attenuation factors (conservative) from subsurface data
    4. Direct measurement of indoor air/exposure concentrations

- Which is the best approach?

# Vapour concentrations based on groundwater data







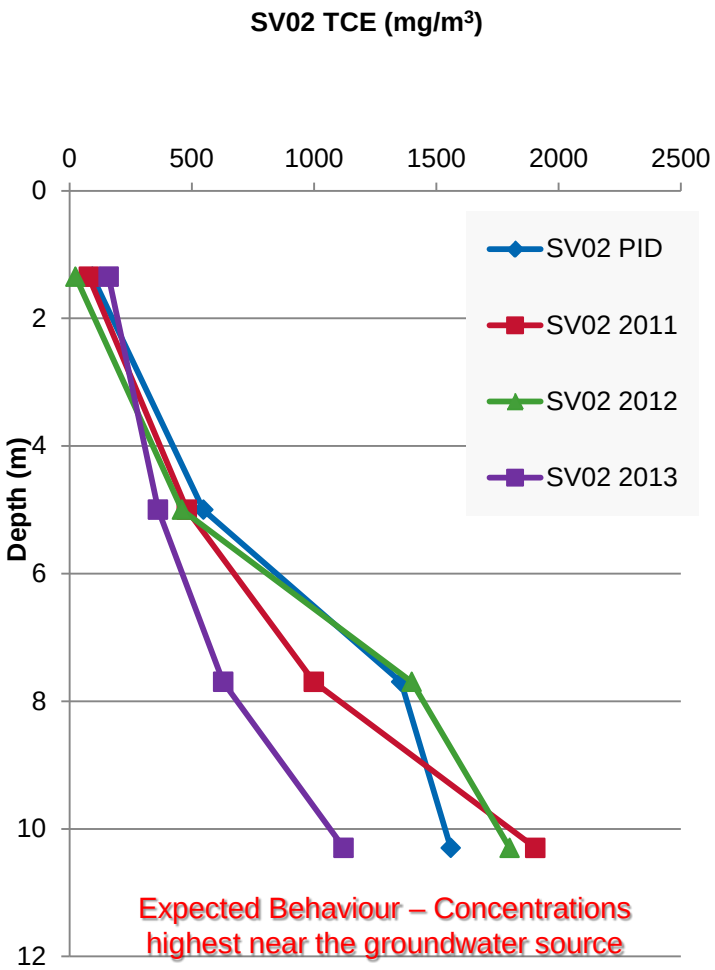
Good correlation with Henry's Law

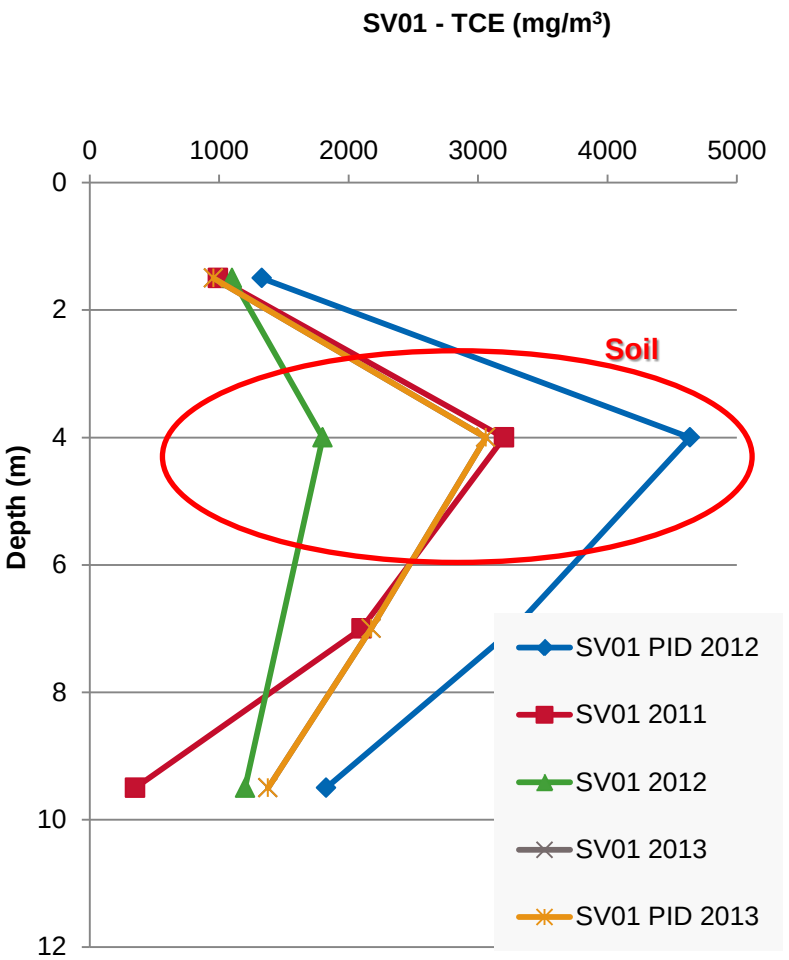



Poor correlation with Henry's Law

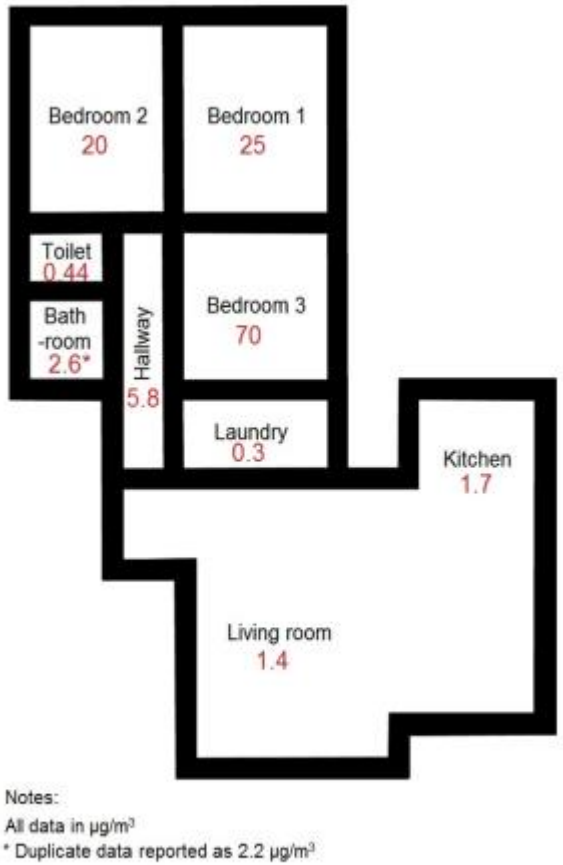
# Identify source term for modelling – nested wells

The source of vapours may not just originate from groundwater, depending upon historic use of the area

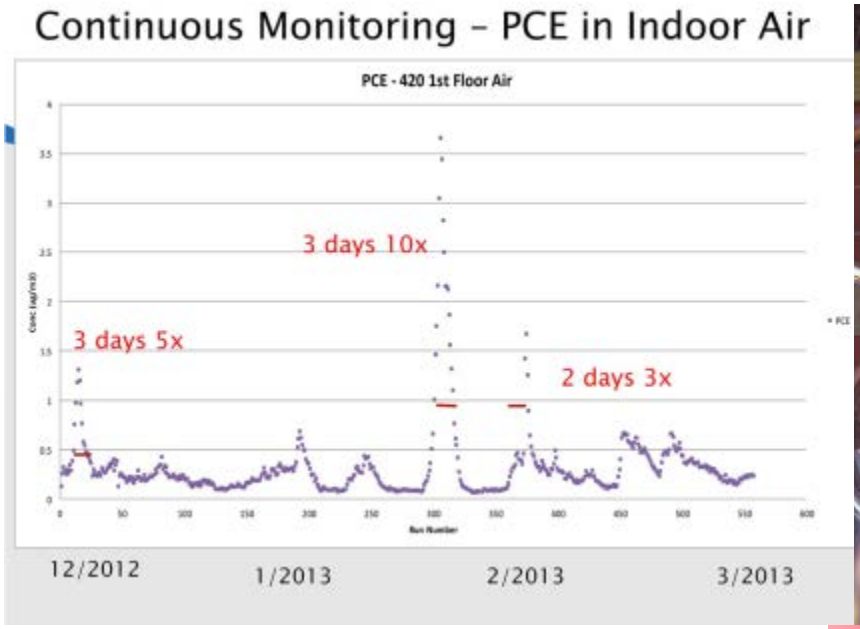


# Indoor Air Data – Is this the best approach?




Notes:
All data in µg/m³
* Duplicate data reported as 2.2 µg/m³



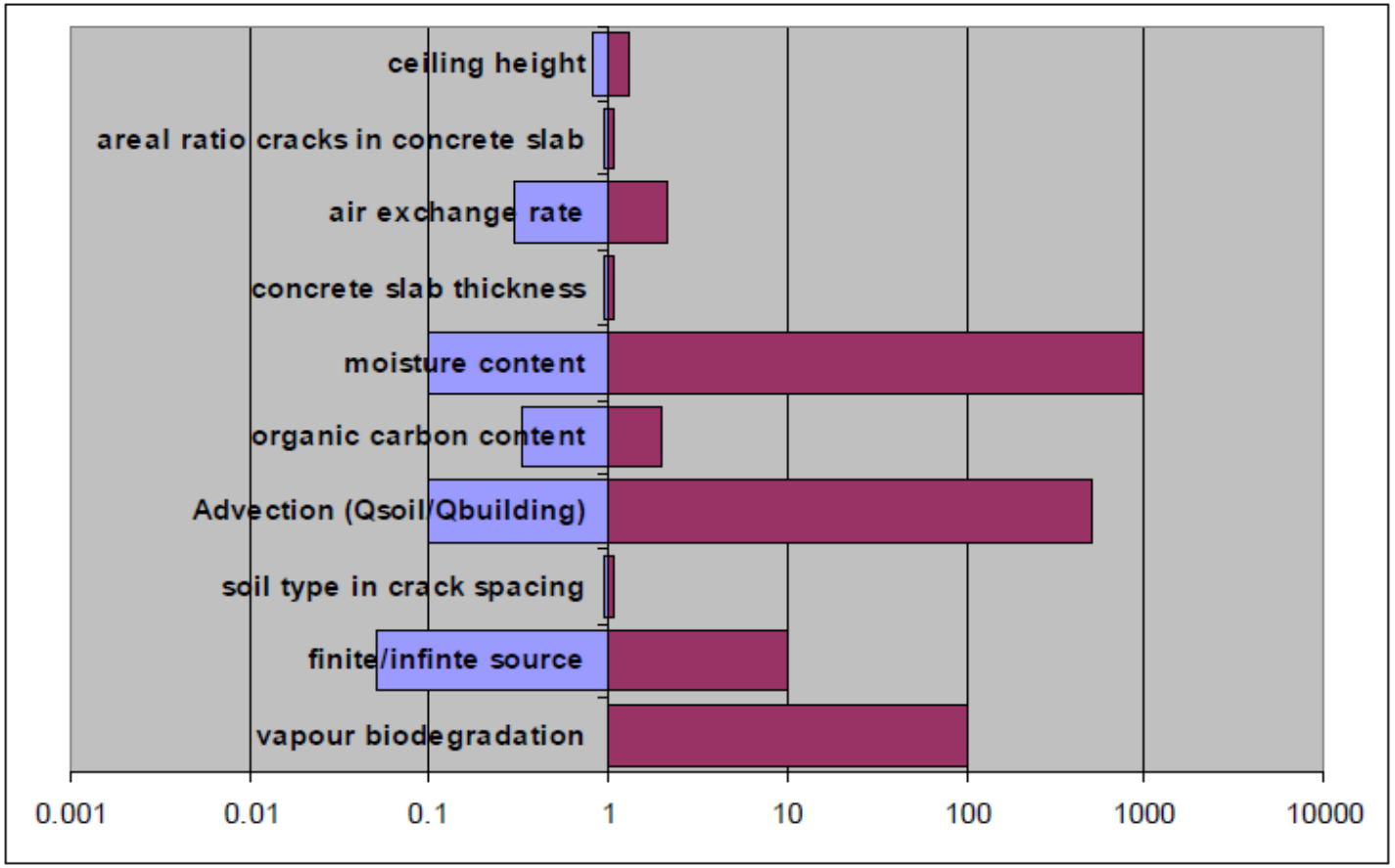

**Temporal Variability Indoors**
**(US Data from Blayne Hartman)**

**Spatial Variability indoors**

# Is modelling the answer then to estimating indoor air concentrations?

- Johnson and Ettinger 1D vapour transport model
- CRC CARE Technical Report 10, Part 3 Sensitivity Analysis Summary

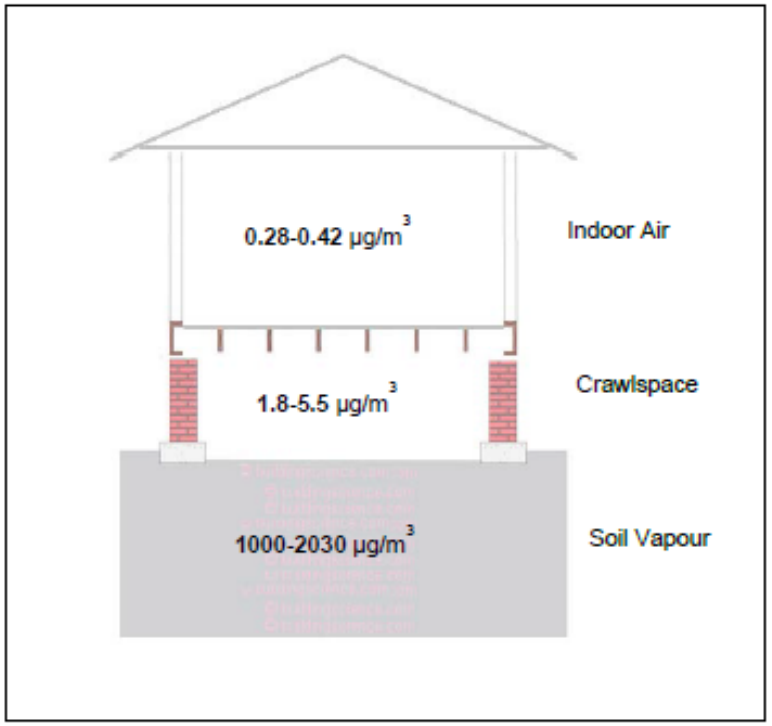
- **Concentrations (risks) can vary by several orders of magnitude depending upon assumptions for key variables**



# Lines of Evidence

- In practice, some **combination of modelling and monitoring is likely to be required** to provide sufficient lines of evidence to adequately assess Vapour Intrusion Risks for TCE


Figure 5-1 Attenuation of TCE Concentrations




- Modelling from groundwater and soil vapour concentrations were compared/calibrated against measured soil vapour, sub-slab and indoor air TCE concentrations.

# Conclusions

- Due to its toxicity, longevity, volatility and historic widespread use, TCE is currently the most problematic volatile environmental contaminant
- It can migrate hundreds of meters or more in groundwater from source sites and can be present at material concentrations for many decades
- Determining potential risks posed by vapour intrusion generally requires multiple lines of evidence and is often a costly exercise

Thanks