

Vapour Intrusion & Indoor Air Quality

Indoor Sources, Building Construction, and Other
Confounding Factors

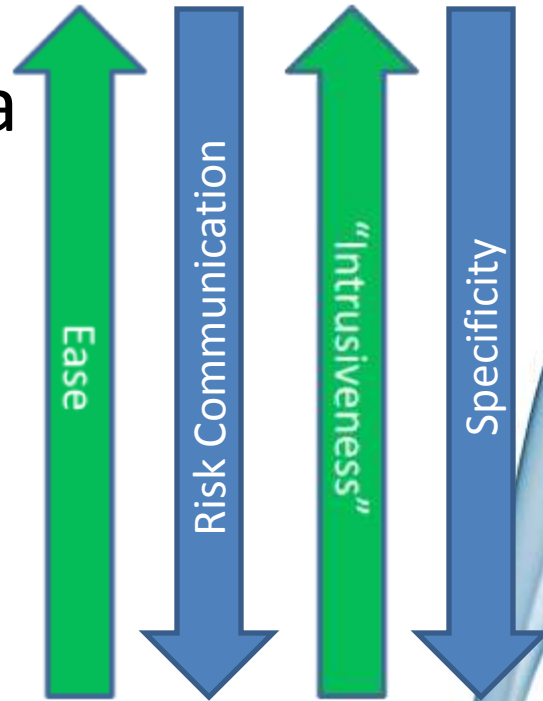
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VI Pitfalls

- Cavalier or Conservative?
- Data Analysis and Exposure Groups
- Screening with models, plug values, and generic attenuation ratios (α factors)
- Community Stakeholders in Charge

Assessing VI IAQ Impacts

- Modeling from GW data
- Deep soil vapour
- Shallow soil vapour
- Sub-slab vapour
- Indoor air quality



IAQ in the Screening Process

U.S. EPA Vapour Intrusion Screening Guidance

Level

IAQ

Tier 1 – Primary Screening



Tier 2 – Secondary Screening



Tier 3 – Site Specific Pathway Assessment



Tier 1 - Primary Screening

- Determine if volatile and toxic chemicals are present (see Table 1).
- Determine if inhabited buildings are, or in the future could potentially be, located near subsurface contaminants:
 - If toxic volatile chemicals are present and current, or future, human exposure is suspected, proceed with screening.
- Determine if potential risks warrant immediate action:
 - If immediate action does not appear to be necessary, proceed to secondary screening.

Tier 2 - Secondary Screening

Question 4

- If indoor air data are available, compare to appropriate target concentration (Table 2a, b, or c).
- If indoor air data exceed the target concentration, proceed to Question 5.
- Determine if there is any potential for contamination of soils in the unsaturated zone:
 - If contamination of the unsaturated zone is suspected, assess soil gas data.
 - If contamination of the unsaturated zone is not suspected, assess groundwater data.
- Compare soil gas or groundwater data to appropriate target concentration (Table 2a, b, or c):
 - If groundwater data exceed the target concentration, assess soil gas data.
 - If soil gas data exceed the target concentration, proceed to Question 5.
- Determine if data are adequate to characterize the site and support an assessment:
 - If adequate data are not available, develop a sampling and analysis plan that satisfies the established data quality objectives.
- Determine if site conditions, or data limitations, would preclude the use of generic attenuation factors used in Tables 2a, b, and c.
- If appropriate data do not exceed target media concentration, pathway is considered to be incomplete.

Question 5

- Determine if there is any potential for contamination of soils in the unsaturated zone:
 - If contamination of the unsaturated zone is suspected, assess soil gas data.
 - If contamination of the unsaturated zone is not suspected, assess groundwater data.
- Compare soil gas or groundwater data to appropriate target concentration (Table 2a, b, or c):
 - If groundwater data exceed the target concentration, assess soil gas data.
 - If soil gas data exceed the target concentration, proceed to Question 6.
- If adequate data are not available, develop a sampling and analysis plan that satisfies the established data quality objectives.
- Determine if site conditions, or data limitations, would preclude the use of scenario-specific attenuation factors used in Tables 2a, b, and c.
- If appropriate data do not exceed target media concentration, pathway is considered to be incomplete.

Tier 3 - Site Specific Pathway Assessment

Question 6

- Determine if the nature and extent of contamination has been adequately characterized to identify the buildings that are most likely to be impacted:
 - If no, develop a sampling and analysis plan that satisfies the data quality objectives.
- Compare sub-slab soil gas or indoor air data to appropriate target concentration:
 - If sub-slab data exceed target concentration, assess indoor air data.
- Determine whether or not site data meet data quality objectives and background/natural sources have been adequately accounted for.
- Determine if exposure pathway is complete.

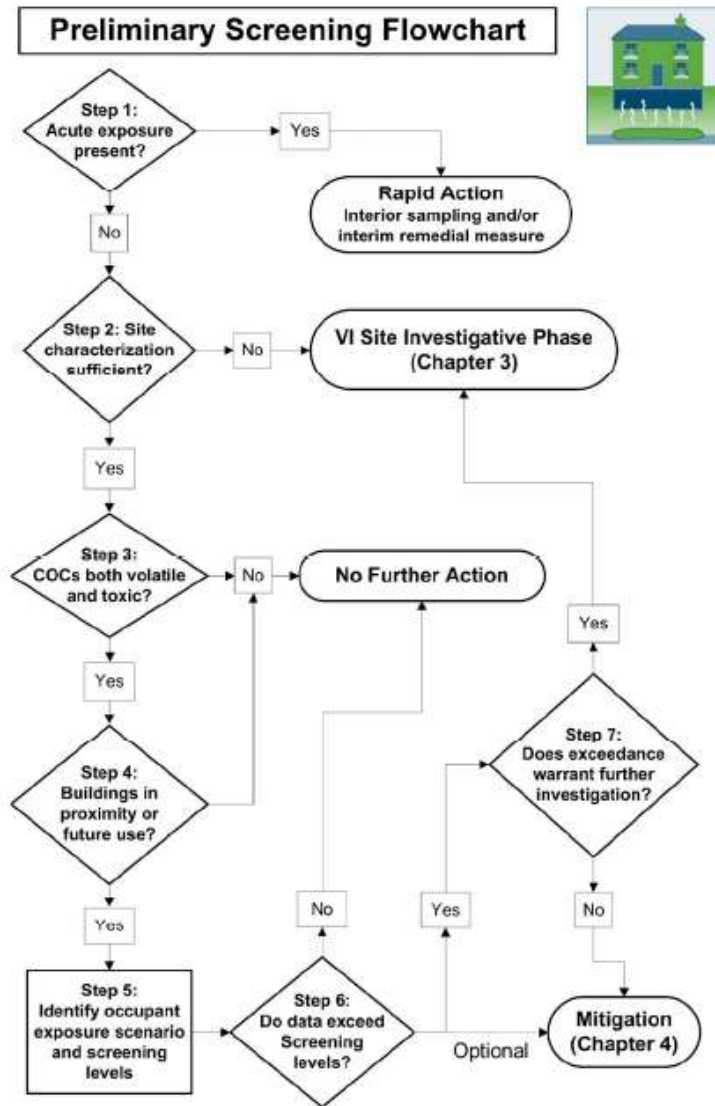


Figure 2-2. Decision-making process for VI preliminary screening.

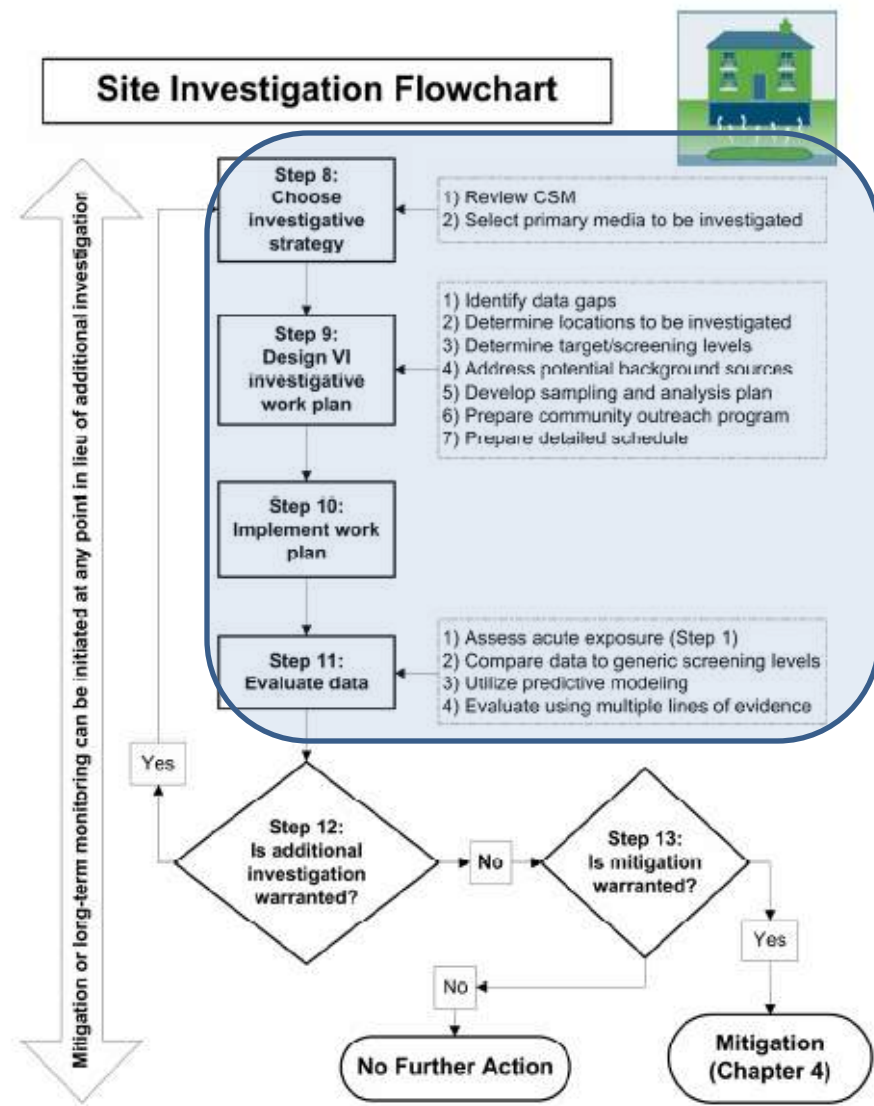
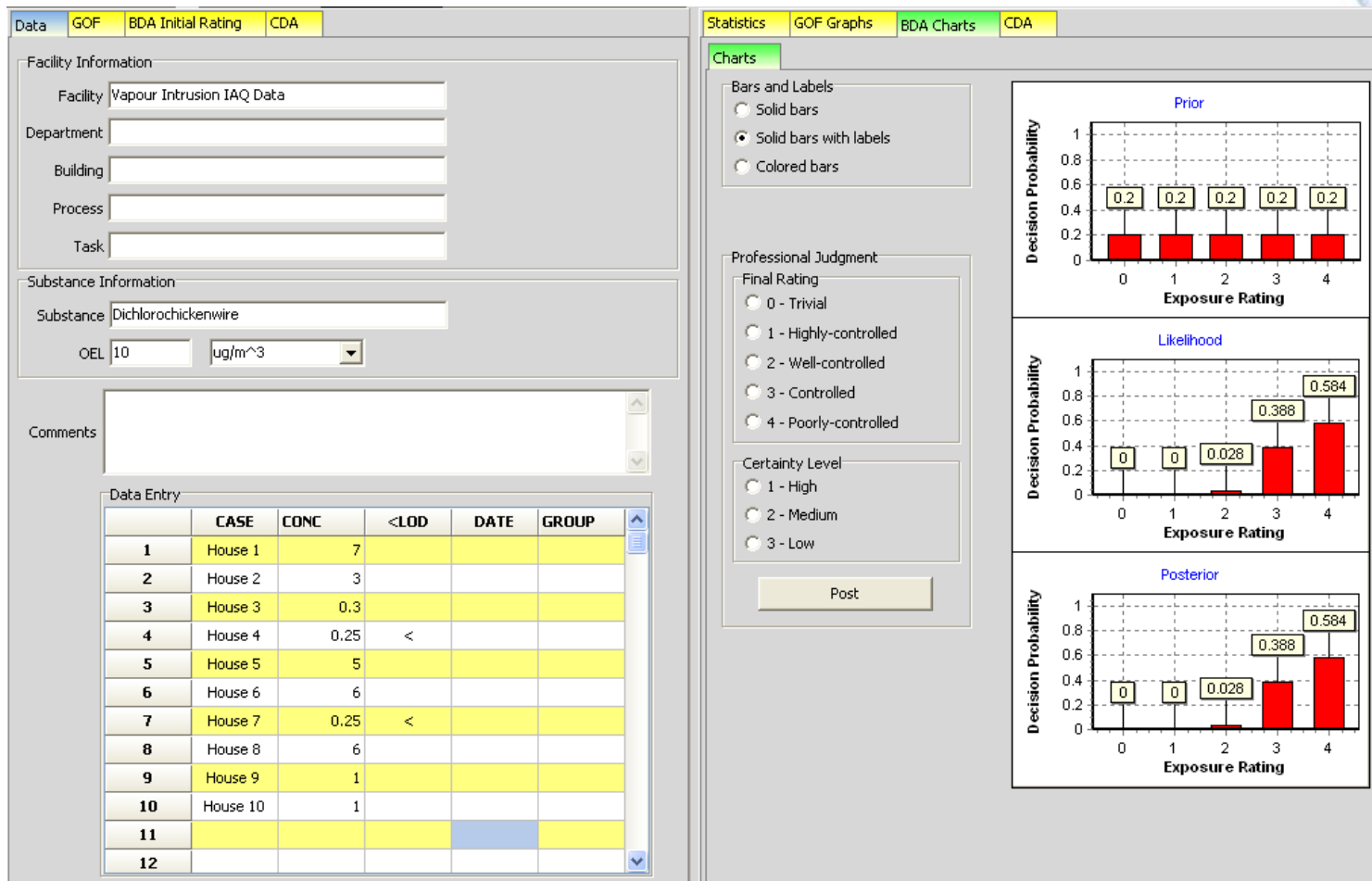



Figure 3-1. Decision-making process for VI site investigation.

Conservative or Cavalier?

Bayesian Decision Analysis



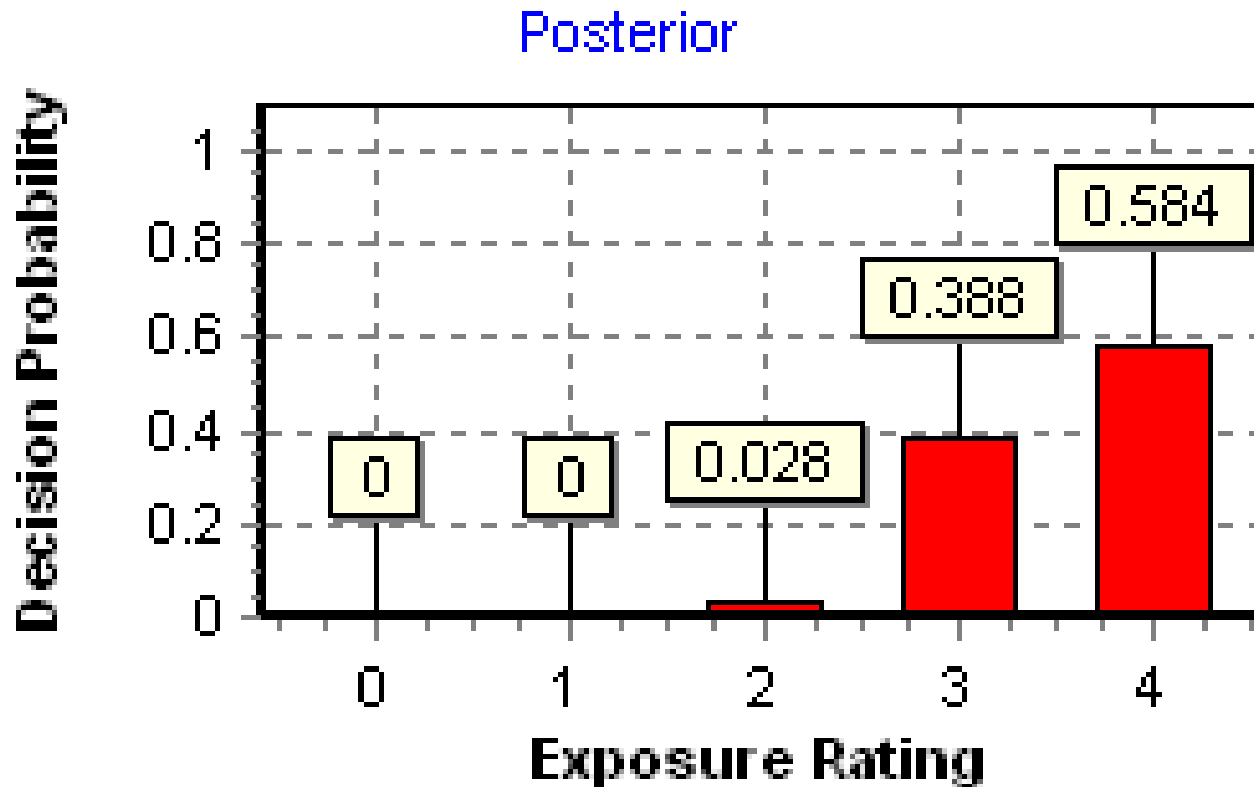
IAQ Exposure Assessment

Category		Action	Probability
0	0-1% of RfC	Exclude	
1	1-10% of RfC	Investigate	
2	10-50% of RfC	Investigate/Continue Monitoring	
3	50-100% of RfC	Continue Monitoring/Remediate	
4	> RfC	Remediate	

Data

ation

CASE	CONC	<LOD
House 1	7	



House 10	1	
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Substance Information

Substance Dichloro

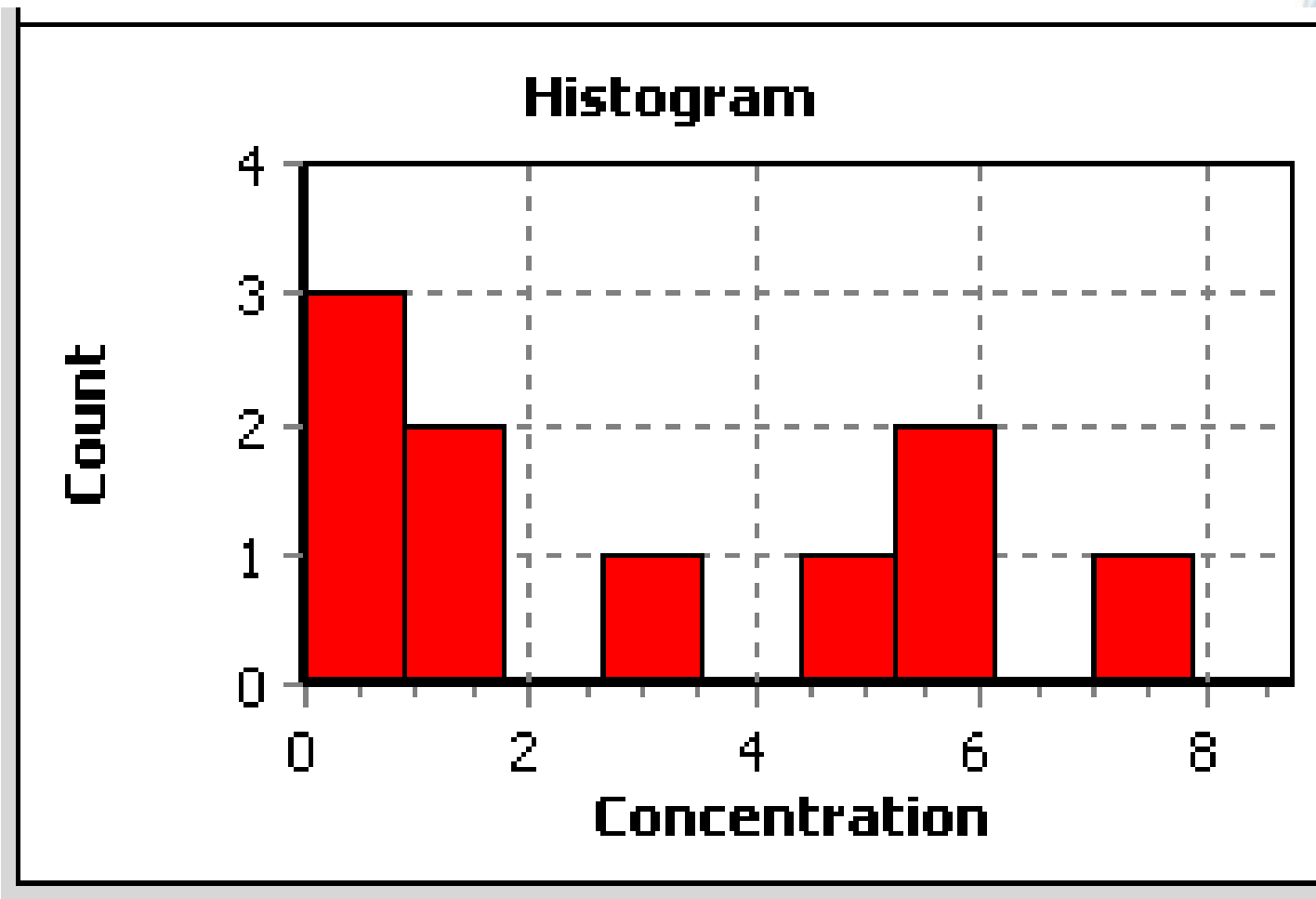
OEL 10

Comments

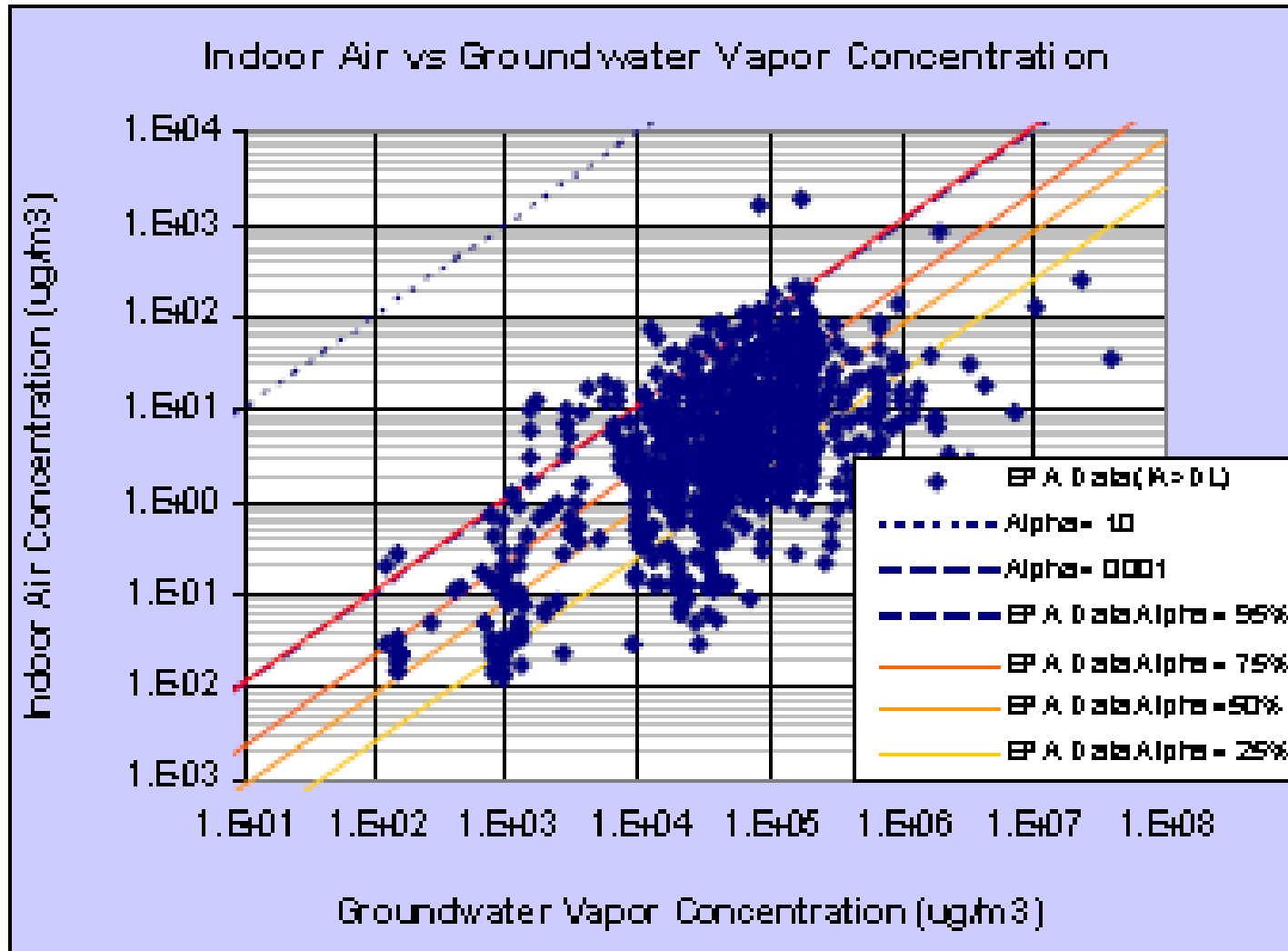
Data Ent

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12

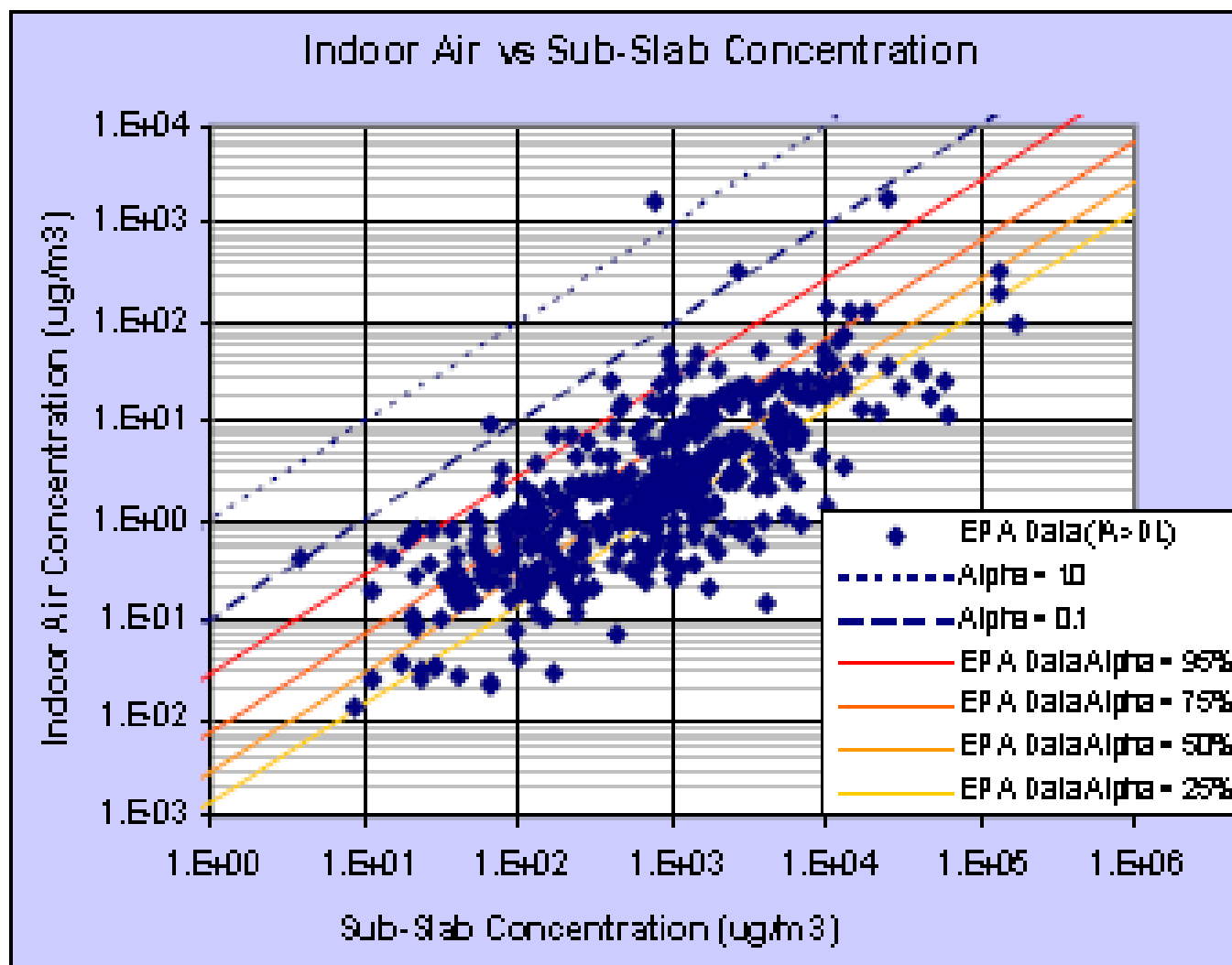
Similar Exposure Groups?



Groundwater to Indoor Air Attenuation (α 's)



Sub-slab to Indoor Air Attenuation



Why the variability?

What confounds measured vapour levels?

- Environmental Factors
- Building Factors
- Sampling Factors

Environmental Factors

- Soil Conditions
- Chemical Concentration
- Source Location
- Groundwater Conditions
- Surface Confining Layer
- Fractures in Bedrock/Clay
- Utilities
- Weather
- Biodegradation



Building Factors



- Pressure Gradients & Vapour Pathways
- HVAC & Combustion Equipment
- Foundation Type and Integrity
- Penetrations, Utilities, Sub-surface Features



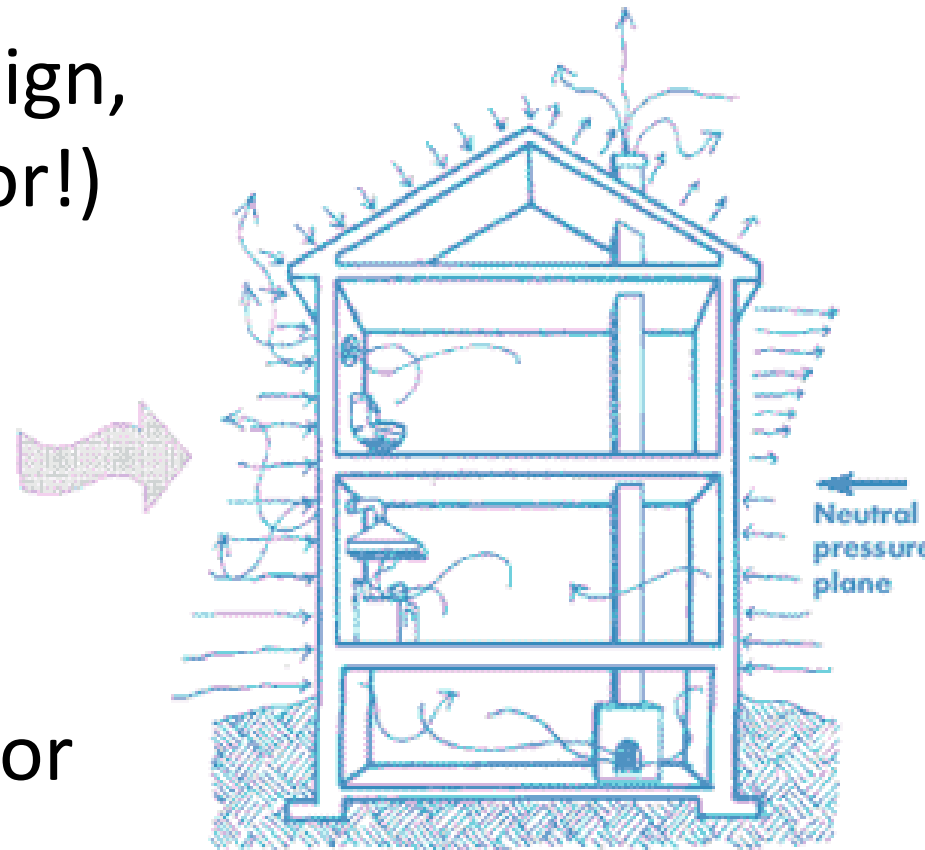
J-E Building Factors of Note

- Exchange Rate
- Mixing Height
- Floorplate
- Foundation Area
- Crack Ratio
- Slab Thickness

$$\alpha = \frac{\left[\frac{D_T^{eff} A_B}{Q_B L_T} \right] \exp\left(\frac{Q_{soil} L_{crack}}{D_{crack}^{eff} \eta A_B} \right)}{\exp\left(\frac{Q_{soil} L_{crack}}{D_{crack}^{eff} \eta A_B} \right) + \left[\frac{D_T^{eff} A_B}{Q_B L_T} \right] + \left[\frac{D_T^{eff} A_B}{Q_{soil} L_T} \right] \left(\exp\left(\frac{Q_{soil} L_{crack}}{D_{crack}^{eff} \eta A_B} \right) - 1 \right)}$$

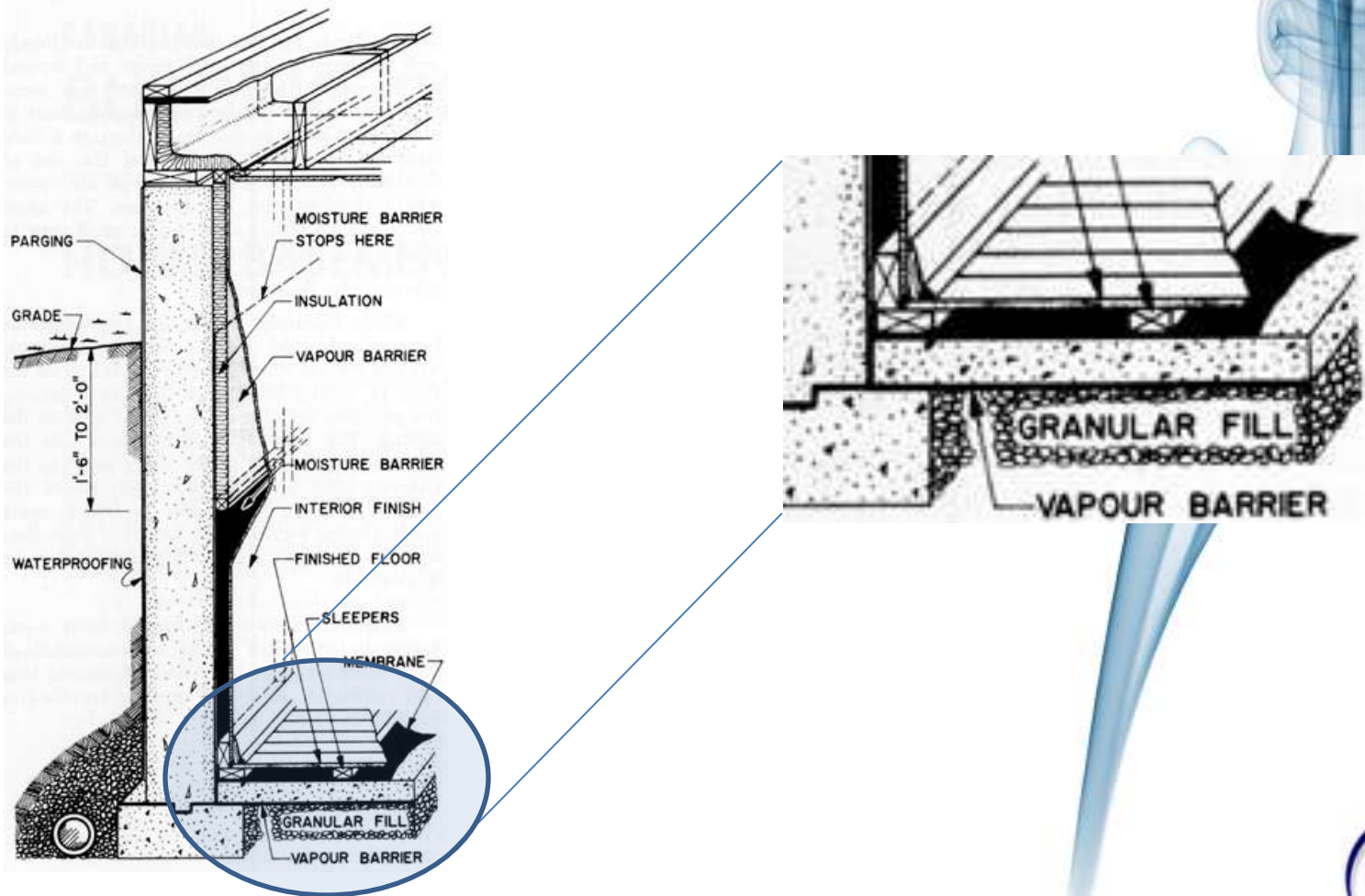
Construction

- Highly Variable (Era, Design, Building Code, Contractor!)
- Passive or Mechanical Ventilation
- Slab, Crawlspace, or Basement?
- Block, poured concrete, or pressure treated foundation?





Construction



Exchange Rates

- ASHRAE IAQ Standard (62.1-2004)
 - 0.35 air changes per hour (ach)
- Measured Air Changes?
 - Mean = 0.65 ach
 - $R_{2000} < 0.05$
- Mixing



Cracking

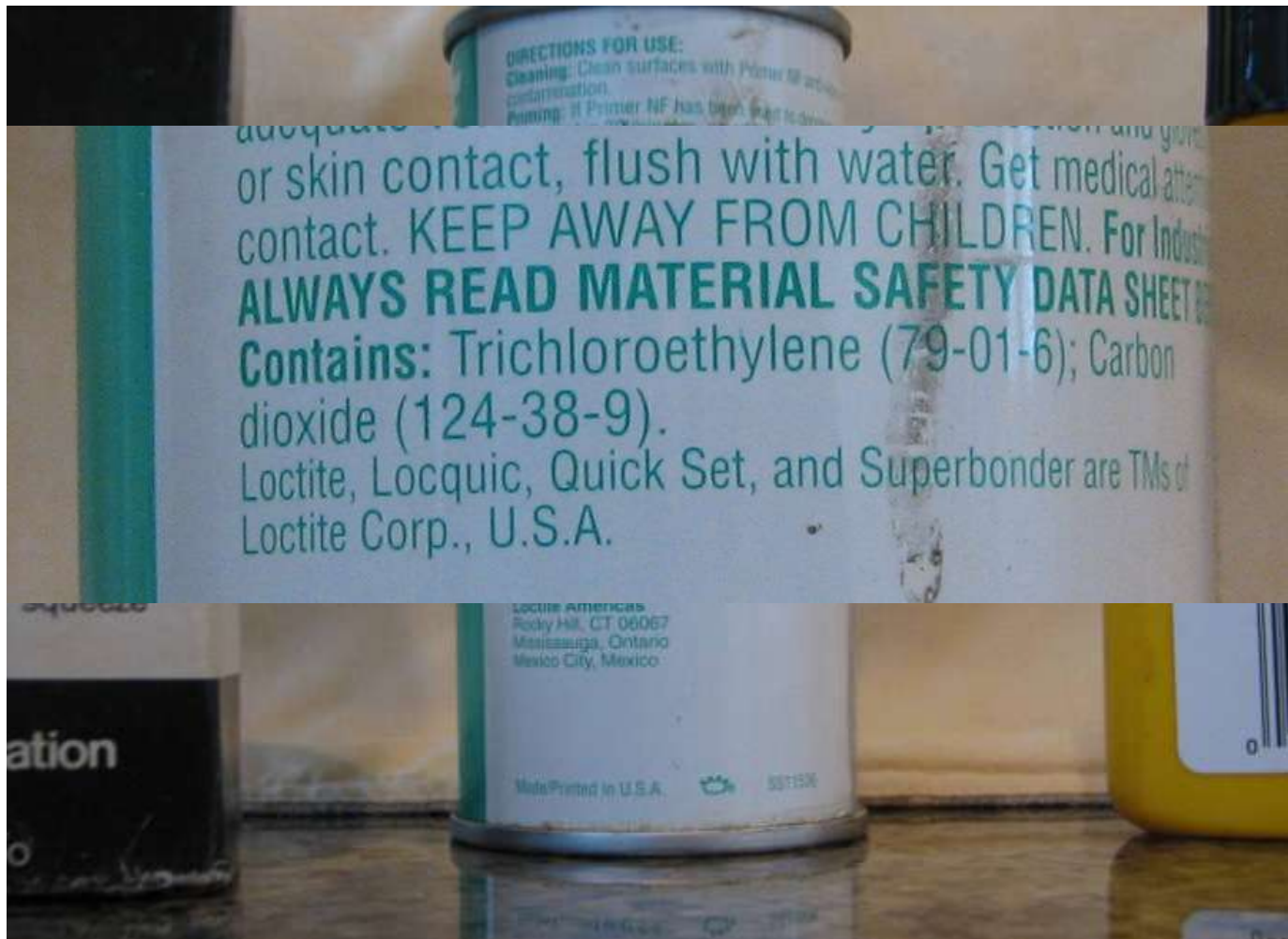


In home sources

- Outdoor Air
- Garages
- Off-gassing
- Household Products
- Occupant Activities
- Indoor Point Sources
- Distinguishing the source can be done



In-home Sources



Summary of Important Factors

- Shallow sources (< 5ft below bldg foundation)
- Crawlspace homes (no barrier) and Suspended Floors
- Very permeable geology
- Significant preferential pathways
- Sources in unsaturated zone
- Very low air exchange rates
- High Pressure Differentials (energy efficiency, makeup and combustion air).

Soil Vapour vs. IAQ

	Soil Vapour	IAQ
Pros	No consultation Higher concentrations No indoor sources	Risk communication Protective Direct comparison Post mitigation
Cons	What depth? Well or push probe required Sampling procedures	Politics & Liability Intrusive (anxiety factor) Trace concentrations Indoor sources

Sampling Vapour/Air

- Whole Air vs. Filtering/Scrubbing
- Sorbent Tubes
- PUF & Treated Filters
- Summa Canisters



“Whole Air” or Sorbent Tube?



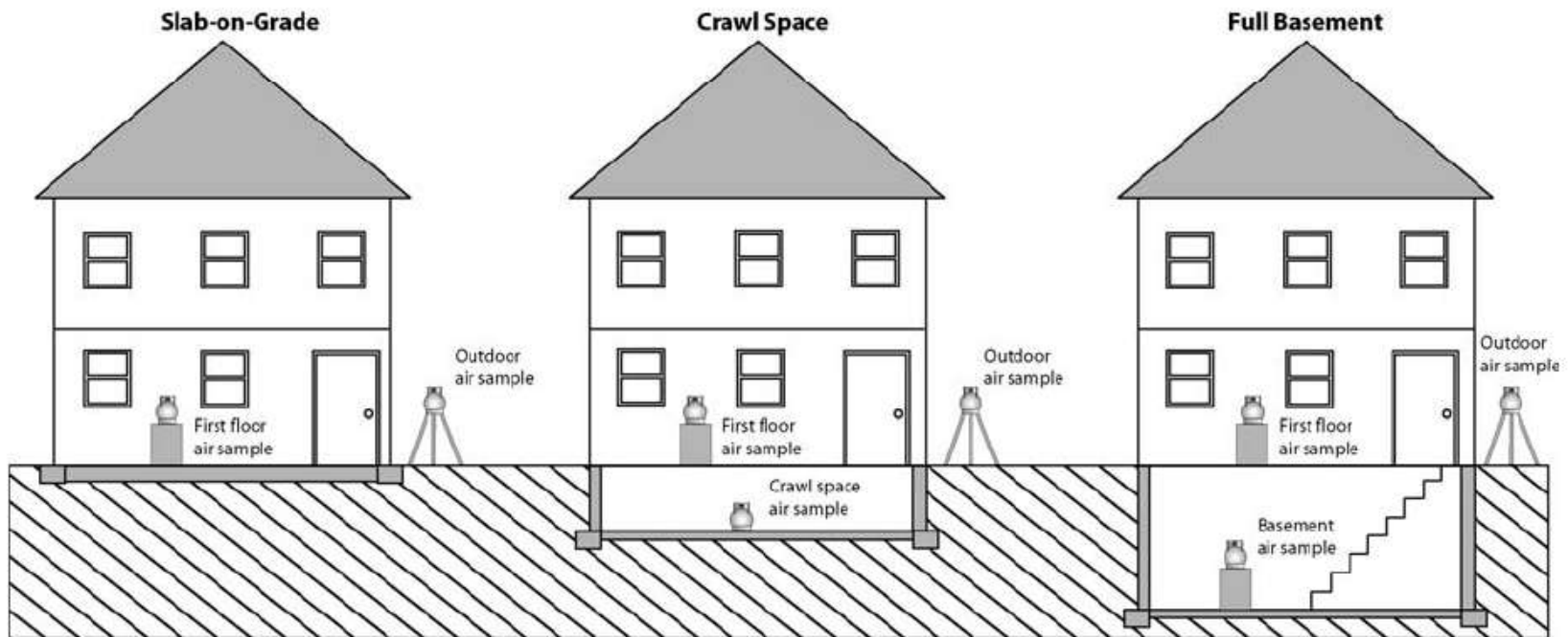
- Target compounds
- Convenience
- Recovery
- Detection Limits
- QA/QC
- Cleaning
- Interferences



Units, Concentration, and Calibration Range

- Soil, water, and vapour ppm/ppb very different things:
 - Soil $1 \text{ mg/kg} = 1 \text{ ppm}$
 - Water $1 \text{ }\mu\text{g/l} = 1 \text{ ppb}$
 - Vapour $1 \text{ }\mu\text{g/m}^3 = 0.001 \text{ }\mu\text{g/l} = ?? \text{ ppb}$
 - Benzene $1 \text{ }\mu\text{g/m}^3 = 0.31 \text{ ppb}$
 - TCE $1 \text{ }\mu\text{g/m}^3 = 0.18 \text{ ppb}$
- Very few methods will resolve $1 \text{ }\mu\text{g/m}^3$
- Working calibration range typically $10 - 100 \text{ }\mu\text{g/m}^3$
- Detection Limits can be very close to risk criteria

Where to sample?



Sampling Procedures

- Soil vapour procedures \neq IAQ procedures
- Procedures and QA/QC critical when measuring ppb levels
- Purge or not to purge?
- Consider what might happen in transport



Sampling Procedures

- Cleaning of media a must, proofing a good idea
- Chilling Sorbent Tubes good, Canisters not so good . . .
- Duplicates, Recovery Spikes, and Tracer Gas where it makes sense



Thank You!



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