IMPROVED INVESTIGATION METHODS TO DISTINGUISH VAPOR INTRUSION FROM INDOOR SOURCES OF VOCS

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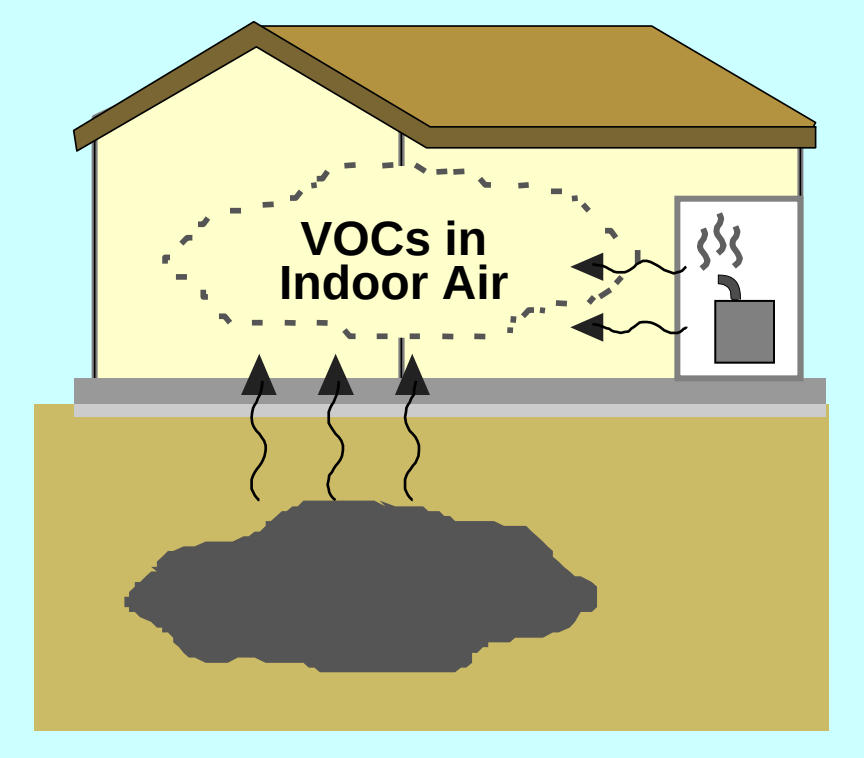
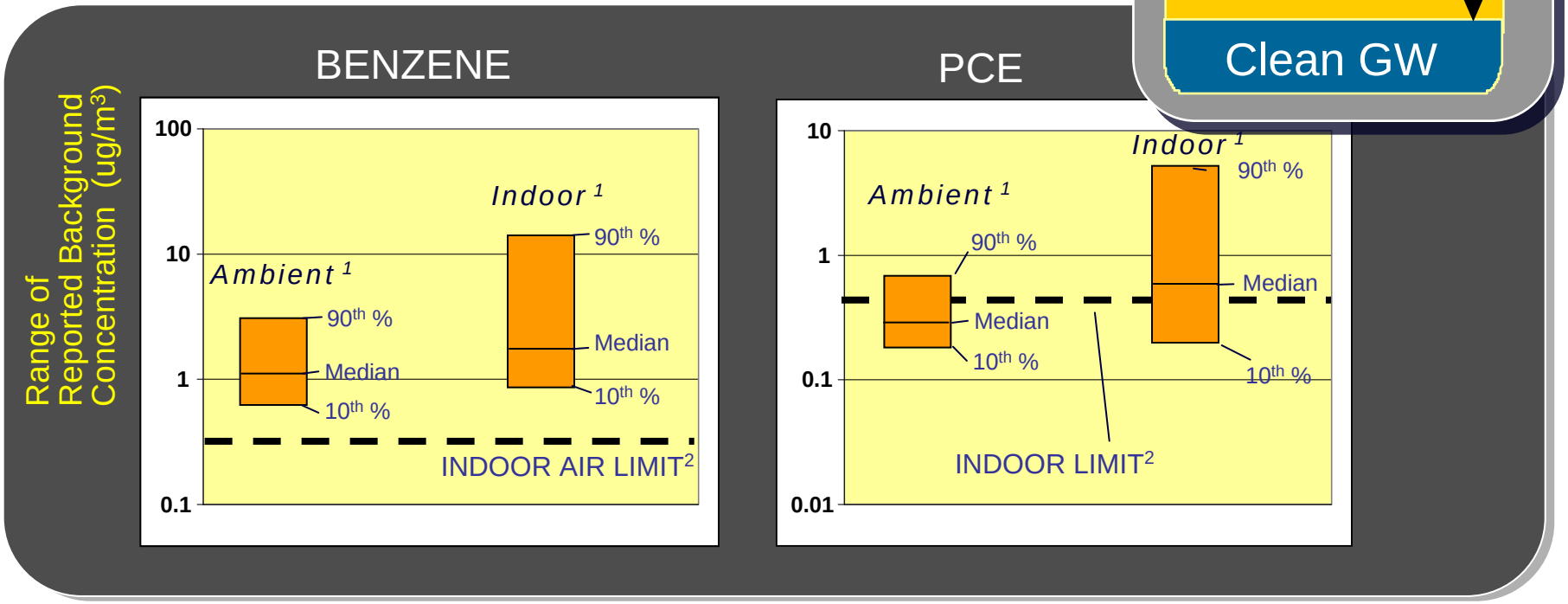
PROBLEM: INDOOR SOURCES

- At vapor intrusion site, testing of indoor air is most direct way to identify VI impacts.
- Indoor sources of VOCs are ubiquitous: cleaners, glues, plastic, etc
- Detection of VOCs in indoor air does not necessarily indicate vapor intrusion.



Key Point: ***Critical need for reliable methods to distinguish between vapor intrusion and indoor sources of VOCs.***

2004 Background vs. USEPA Risk-Based Limits



KEY POINT: Background indoor and outdoor air concentrations commonly exceed risk-based limits for indoor air.

1) Background concentrations from Sexton et al. 2004 ES&T 38(2); 423-430.
2) USEPA Master Screening Values Table, September 2008

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Consumer Products Containing PCE

Product	PCE Concentration
ARAMCO Art and Crafts Goop	Not Specified
Aleenes Patio & Garden Adhesive	70%
Gumout Brake Cleaner	50 - 90%
Liquid Wrench Lubricant w/ Teflon	65 - 80%
Plumbers Goop Adhesive	67.5%
Hagerty Silversmith Spray Polish	30.5%
Champion Spot it Gone	20 - 25%

KEY POINT: Wide variety of consumer products still contain high concentrations of PCE.

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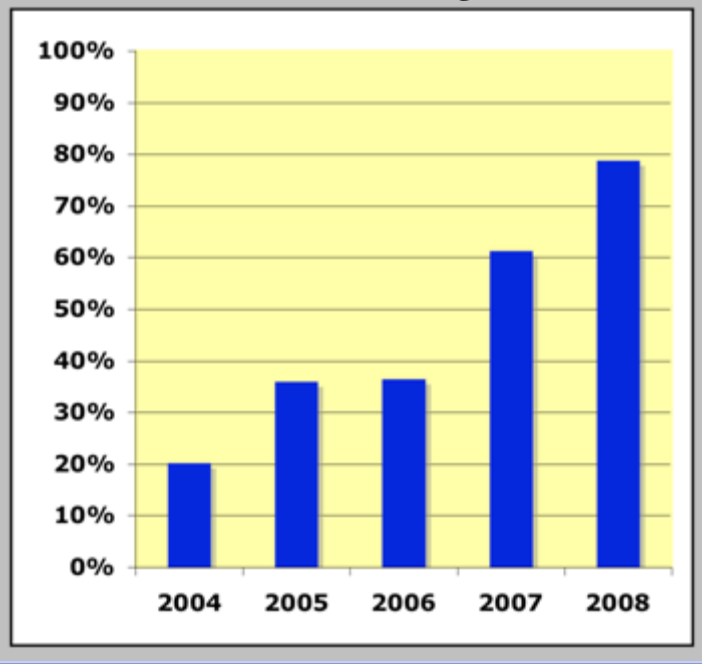
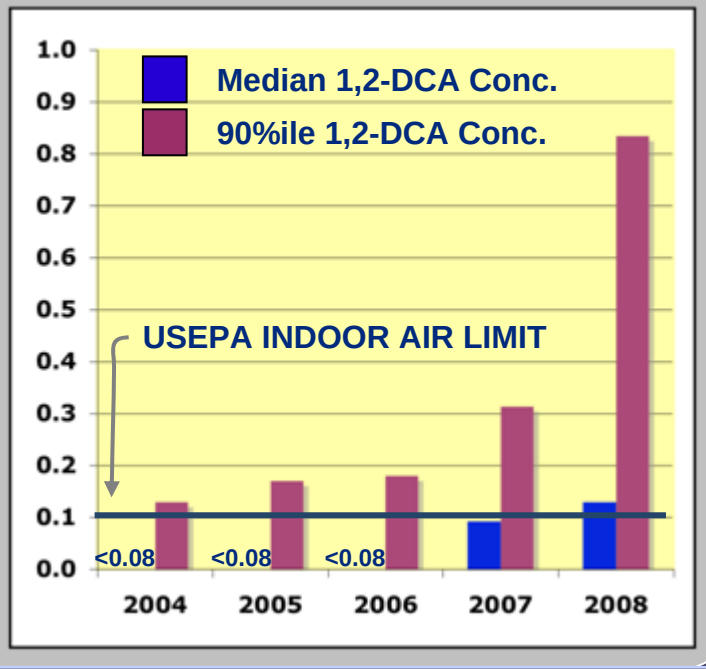
Source: http://householdproducts.nlm.nih.gov/cgi-bin/household/brands?tbl=chem&id=177

New Indoor Source of 1,2-DCA

DETECTION FREQUENCY



CONCENTRATION



KEY POINT: Indoor concentration of 1,2-DCA increasing over time. New indoor source = molded plastic (e.g., toys, Christmas decorations).

Note: 1) 1,2-DCA = 1,2-dichloroethane

2) Indoor 1,2-DCA data from residential area in Colorado. Data provided by Jeff Kurtz, Envirogroup (jkurtz@envirogroup.com)

Reference: Doucette, Hall, and Gorder, 2010, "Emission of 1,2-dichloroethane from holiday decorations as a source of indoor air contamination", accepted for publication in GWMR.

SOLUTION: TEST METHODS

POTENTIAL METHODS TO DISTINGUISH BETWEEN VAPOR INTRUSION AND INDOOR SOURCES OF VOCS

Real-time On-site Analysis	■ Used successfully by EPA and Hill AFB ■ Requires expensive equipment: Hapsite GC/MS or USEPA TAGA unit
Building Pressure Control	■ Current ESTCP Project ER-0707 ■ May not be suitable in very large or very leaky buildings
CSIA / Fingerprinting	■ Completed "Proof of Concept" study ■ Additional funding for development and validation

KEY POINT: ***Multiple methods available to distinguish between vapor intrusion and indoor sources.***

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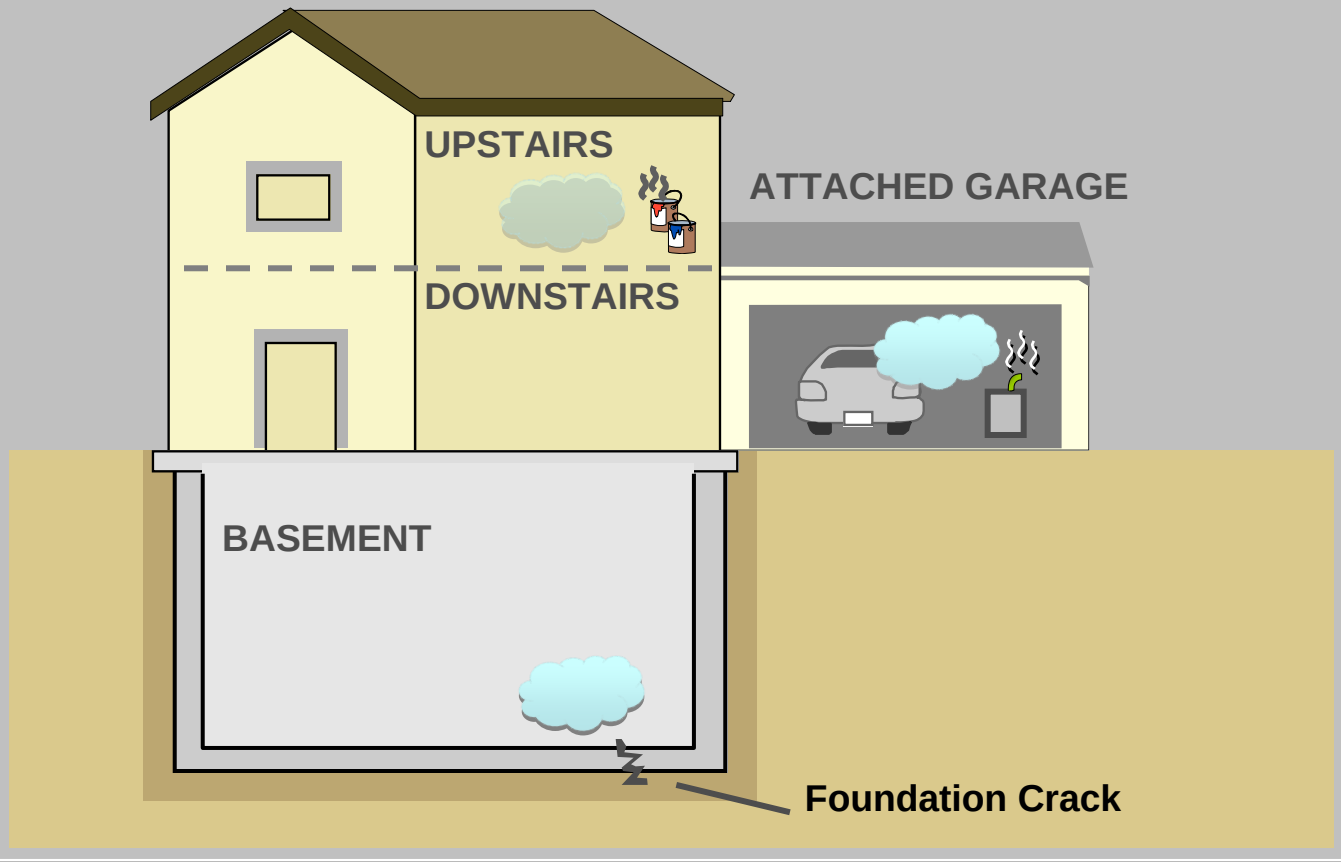
On-Site Analysis: Overview



KEY POINT:

- **Conduct initial survey of buildings**
- **Follow-up in area of highest concentration to identify source.**

ON-SITE ANALYSIS: OPTIONS

	Performance
USEPA TAGA Unit	Continuous analysis with 1 – 5 ppbv quantitation limits (wow!)
HAPSITE Portable GC/MS	<1 ppbv detection limit for grab samples Less sensitive in survey model (i.e., continuous reading)
Mobile lab GC/MS	<1 to 10 ppbv detection limit for grab samples Need alternate instrument for survey

TAGA Unit

HAPSITE GC/MS

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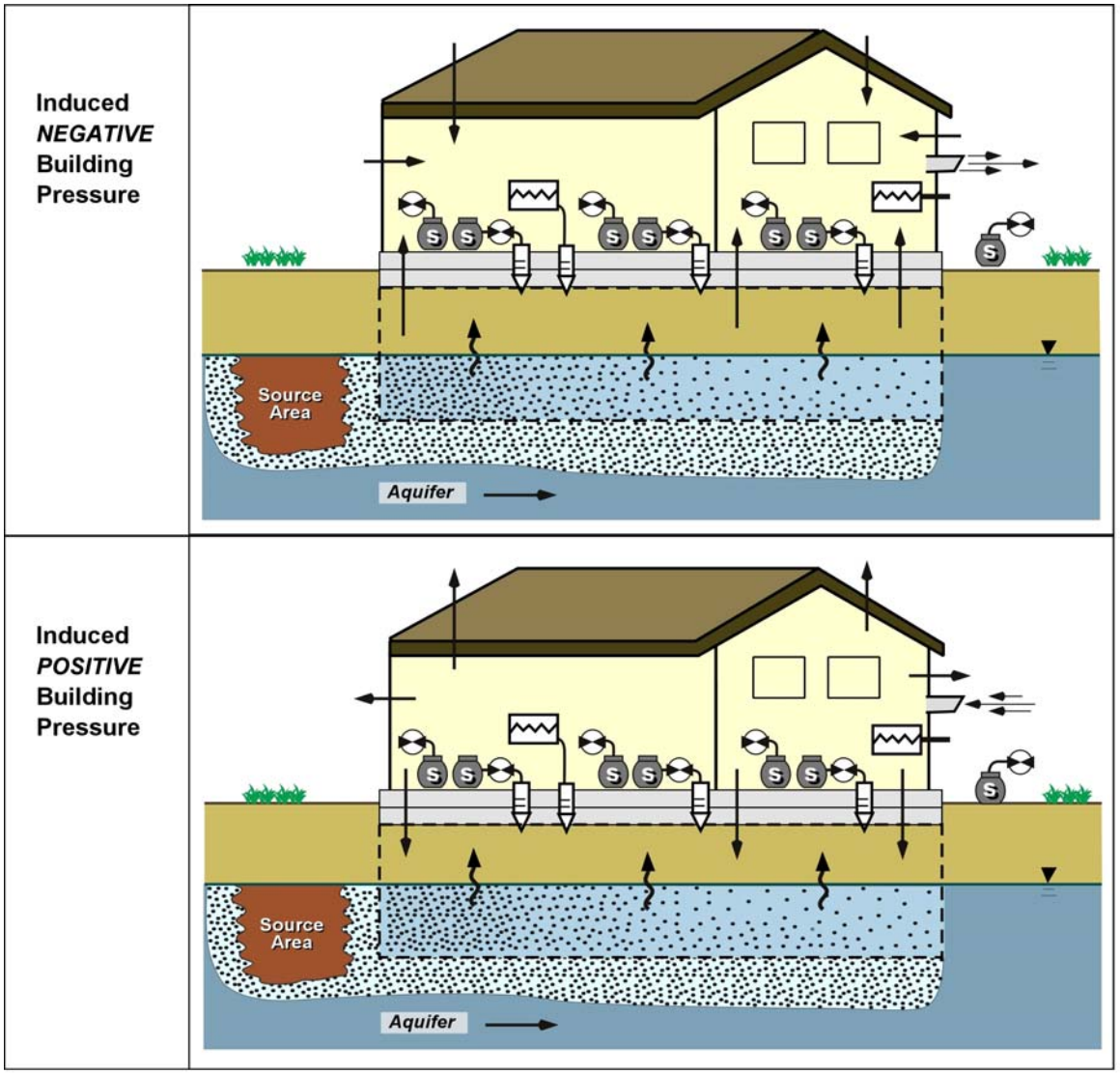
PRESSURE CONTROL: OVERVIEW

Concept:

1) Use controlled <u>NEGATIVE</u> building pressure to <u>MAXIMIZE</u> vapor intrusion.

2) Use controlled <u>POSITIVE</u> building pressure to <u>TURN OFF</u> vapor intrusion.



PRESSURE CONTROL: VALIDATION STUDY TESTING PROGRAM

Matrix	Number of Samples	Analyte	Location
Indoor air	6	Radon, SF6, VOCs	Indoors, 3 locations (negative pressure and positive pressure events)
Sub slab vapor	6	Radon, SF6,VOCs	Sub-slab, 3 locations (negative pressure and positive pressure events)
Ambient air	1	Radon, SF6, VOCs	Outdoors, upgradient, once at each location
Pressure Gradient	NA	Differential pressure between indoor/outdoor and indoor/sub slab space	Continuous sampling at various sample points during positive and negative pressure conditions

TIER 3: FIELD PROGRAM

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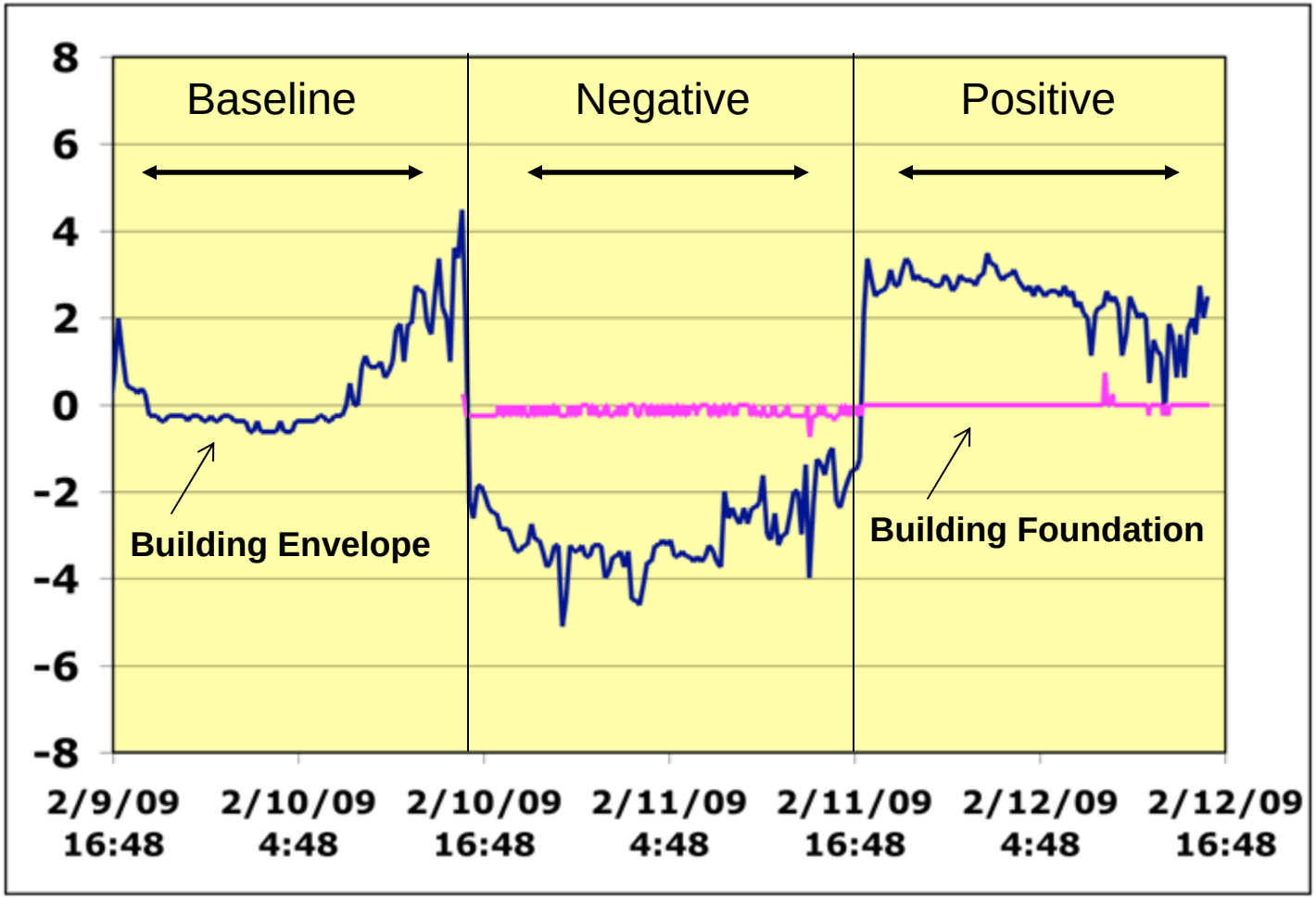
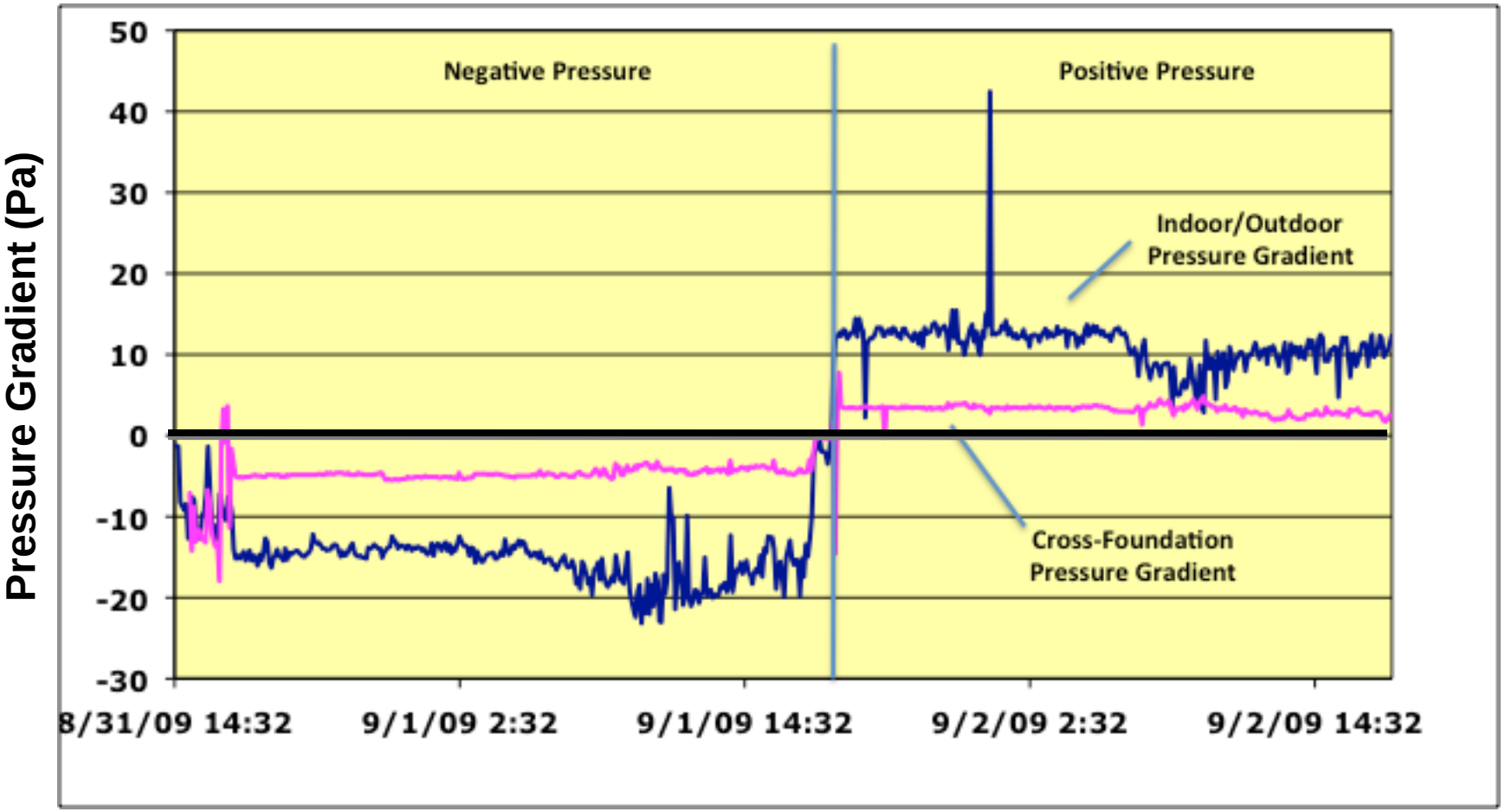
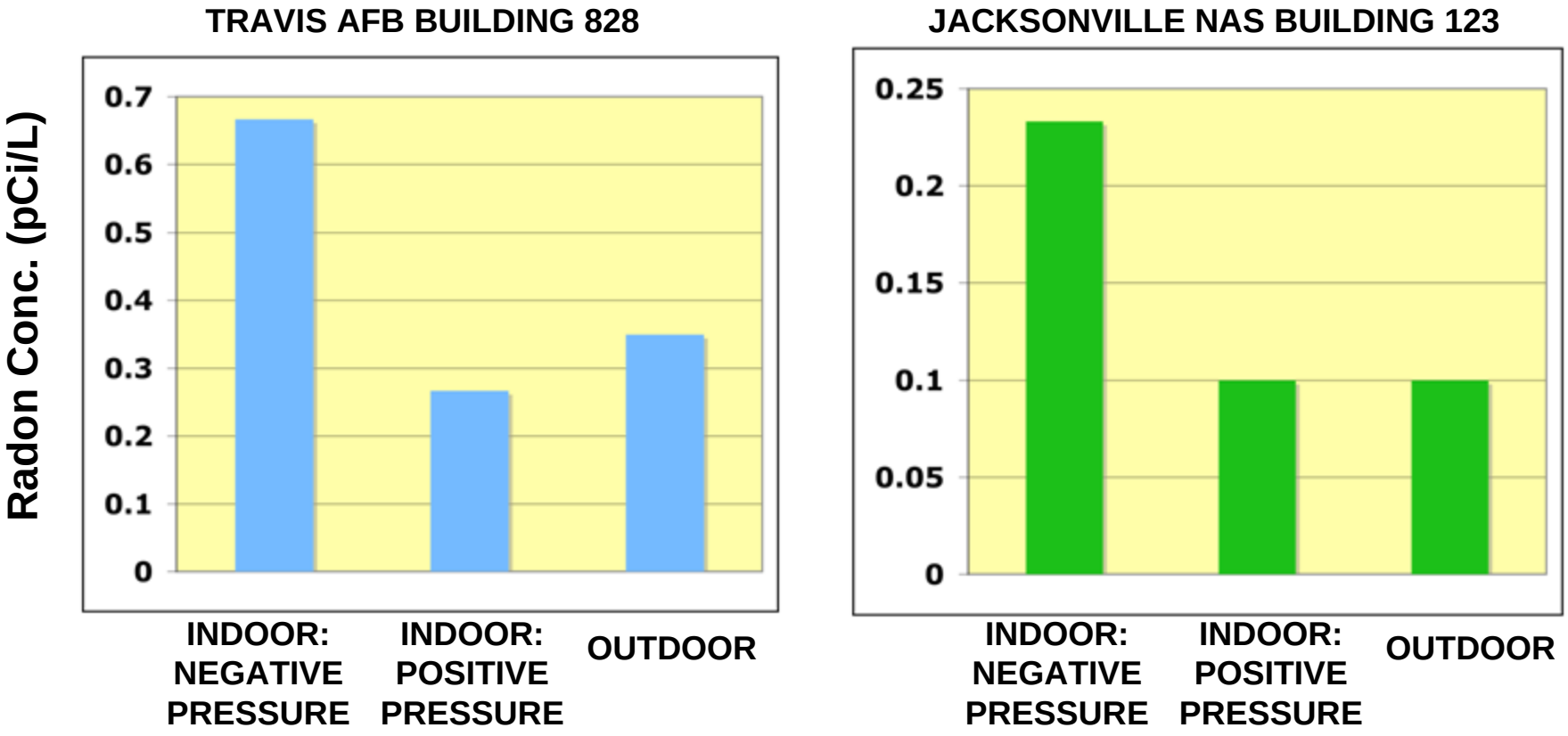
TRAVIS AFB: BUILDING PRESSURE



TINKER AFB: BUILDING PRESSURE

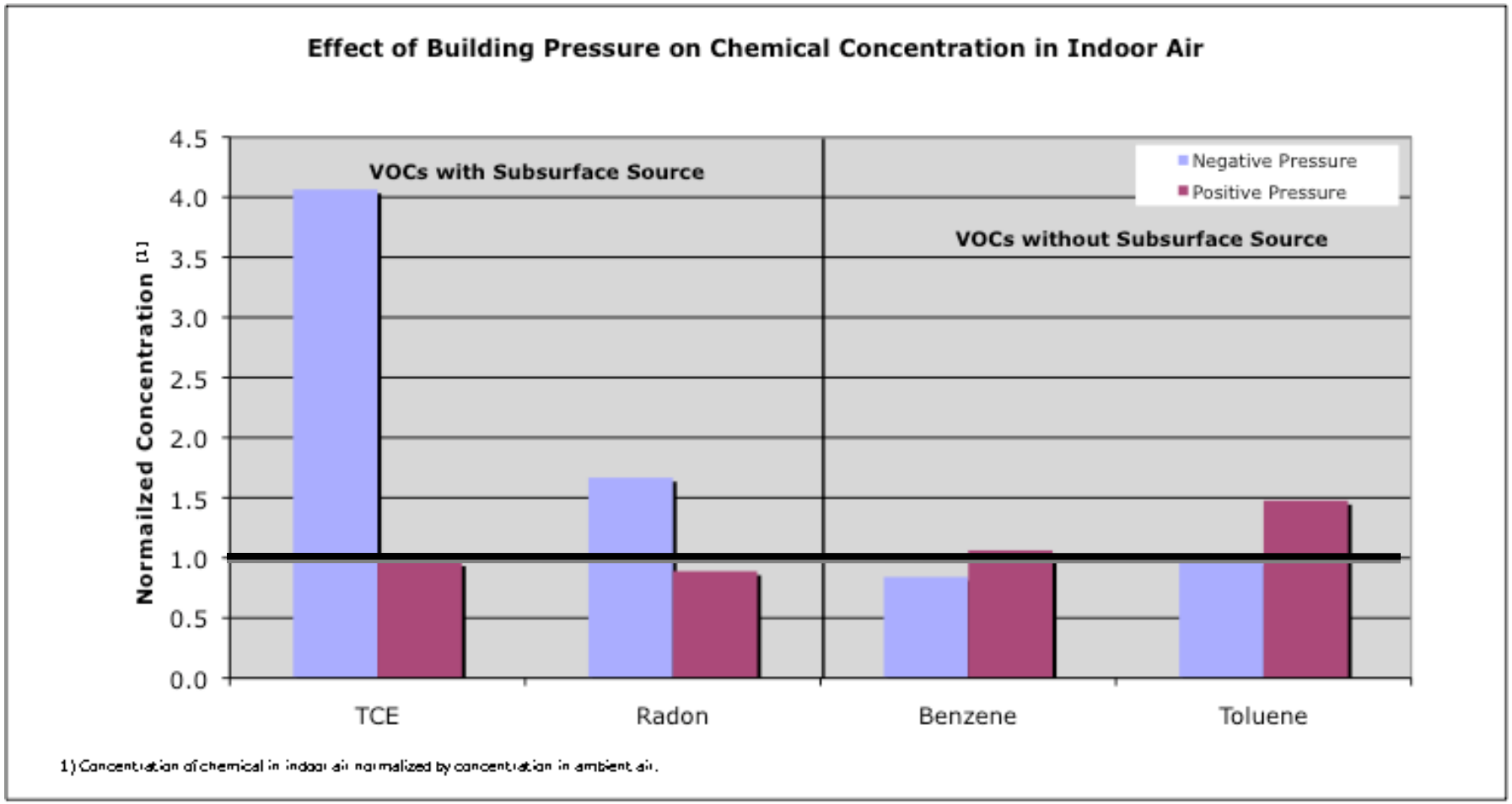


EFFECT OF BUILDING PRESSURE ON INDOOR RADON CONCENTRATION

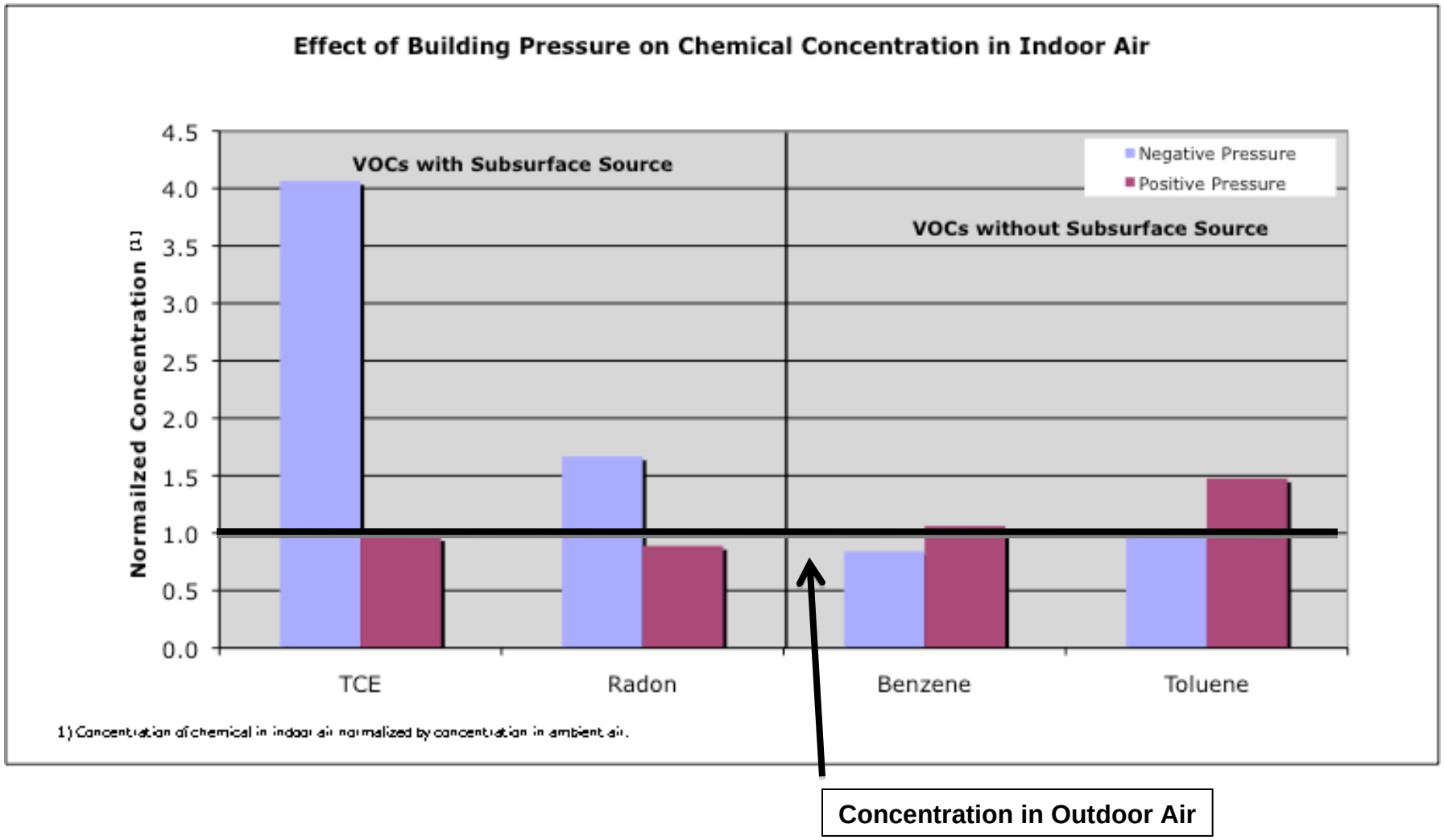


Key Point: **Control of building pressure resulted in control of radon vapor intrusion.**

TRAVIS AFB: INDOOR VOC CONC.



TRAVIS AFB: INDOOR VOC CONC.



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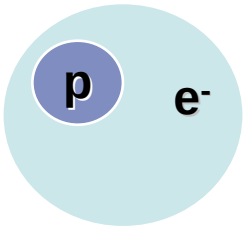
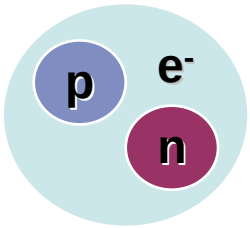
TECHNOLOGY DESCRIPTION

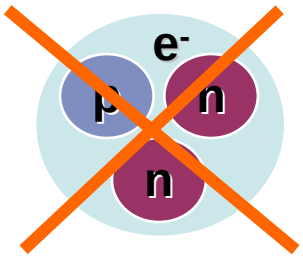
What are Stable Isotopes?



Hydrogen,
^{1}H



Deuterium,
^{2}H, D



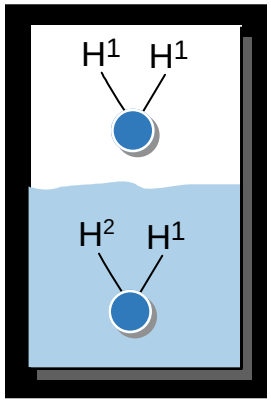
Tritium,
^{3}H, T

- Isotopes have the same number of protons – identical atomic number
- Isotopes have different number of neutrons – different atomic mass
- Stable isotopes do not undergo radioactive decay – tritium is not a stable isotope

TECHNOLOGY DESCRIPTION

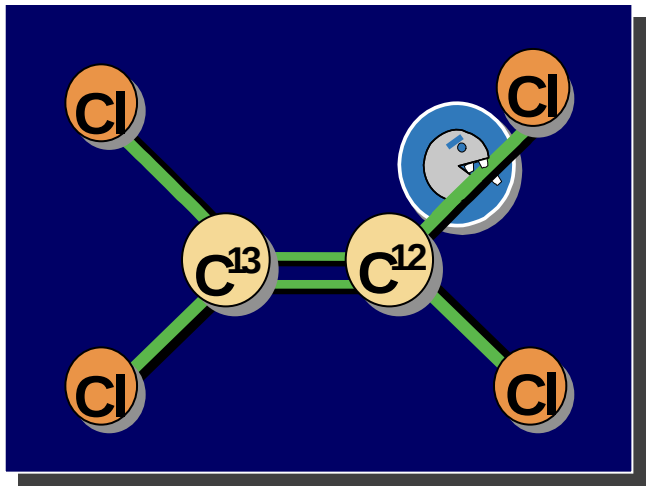
Stable Isotope Fractionation

Equilibrium Effect (reversible)



Evaporation

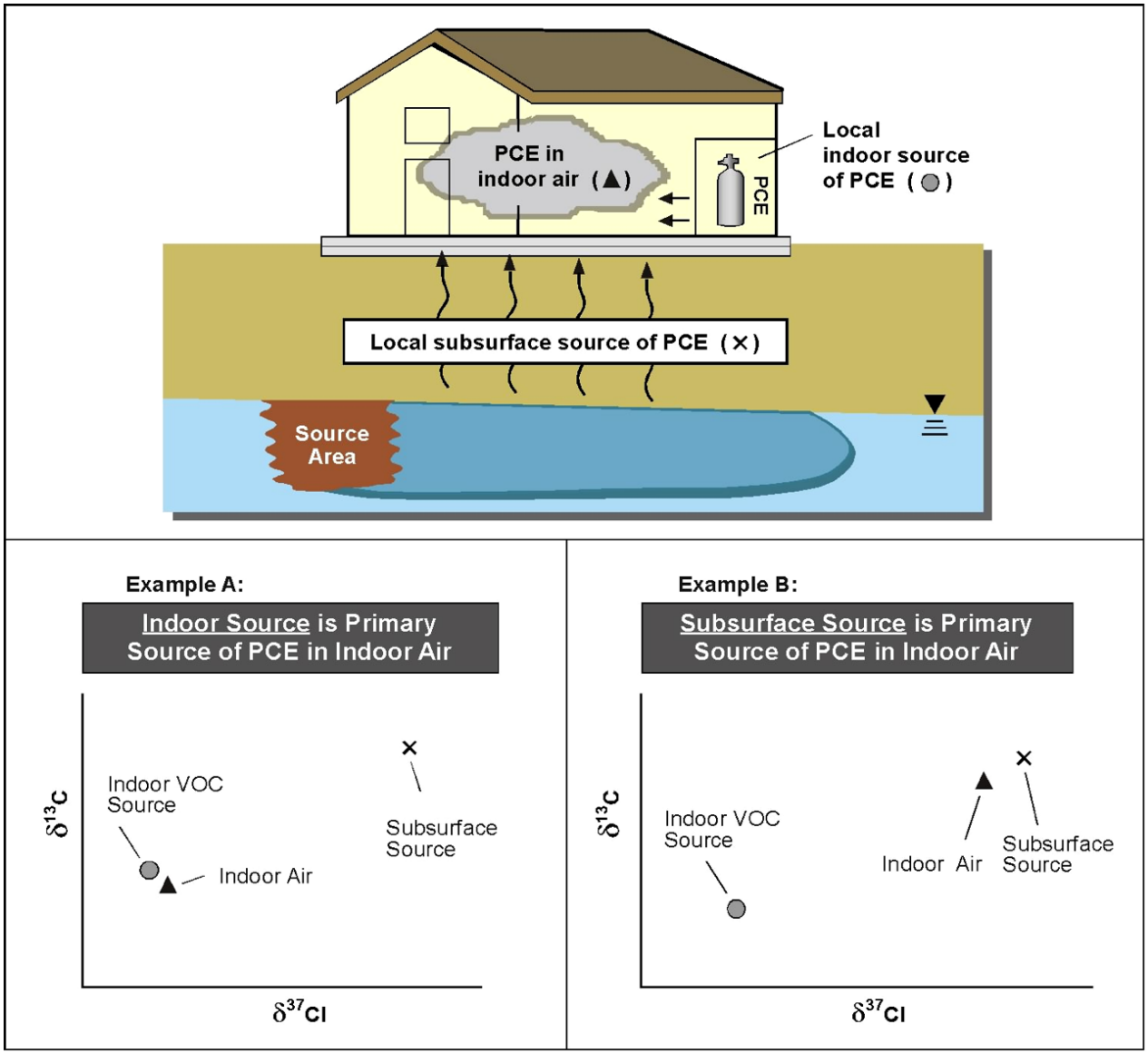
Kinetic Effect (irreversible)



Biodegradation of PCE

Key Point: ***Differences in isotope ratios between samples can indicate different sources.***

TECHNOLOGY DESCRIPTION



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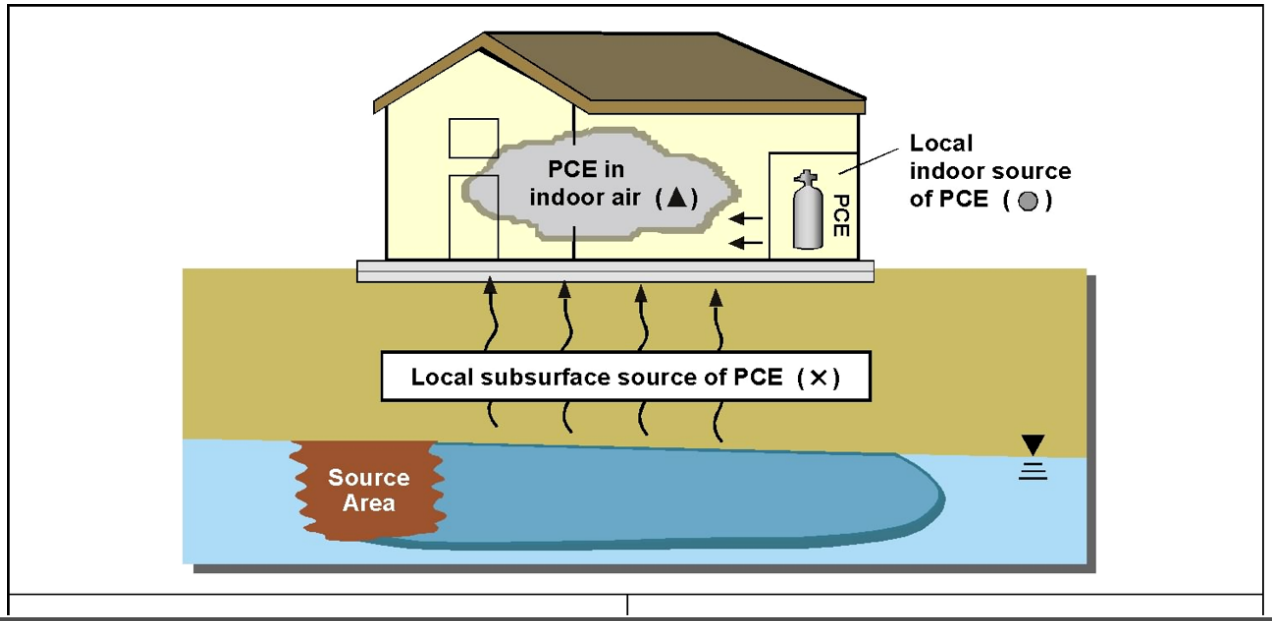

Isotope Differences: Indoor vs. Subsurface Sources

<u>Manufacturing</u>: Consumer products vs. industrial chemicals.

<u>Biotransformation</u>: Kinetic isotope effects likely in subsurface sources but not indoor sources.

CSIA: PROOF OF CONCEPT

Small Study at Hill AFB: Can this work?

4 Indoor Sources

- TCE $\delta^{13}C$ = -26.6‰ to -25.2‰.

3 Sub-surface Samples

- TCE $\delta^{13}C$ = -25.3‰ to -24.4‰
- Heavier than indoor source samples.
- p = 0.014

2 Indoor Air Samples

- TCE $\delta^{13}C$ = -26.8‰ & -26.6‰.
- Consistent w/ indoor sources.

Testing of Indoor TCE Sources

FUTURE EFFORTS

Validation of Vapor Intrusion Tools

- AFCEE BAA 2009 Award
- Application of CSIA, Molecular Biological Tools, and other innovative analyses to vapor intrusion
- Broader scope (indoors and vadose zone)
- Work to be conducted at Hill AFB

2010 Start ESTCP Project?

- Develop and validate protocol for application of CSIA to distinguish between vapor intrusion and indoor sources of VOCs
- Short listed for 2010 ESTCP funding

Petroleum Fingerprinting

- Use hydrocarbon fingerprinting to distinguish between vapor intrusion and indoor sources of petroleum hydrocarbons
- Industry funding

RECMMENDATIONS

POTENTIAL METHODS TO DISTINGUISH BETWEEN VAPOR INTRUSION AND INDOOR SOURCES OF VOCS

Multiple Approaches

- Need range of methods (likely to vary in cost, complexity, equipment)
- Best method likely to vary by chemical and building

Protocols

- For each method, develop standard protocol for application:
  - general approach, number & type of samples, data interpretation, etc.

Validation

- Coordinate between interested parties to validate investigation protocols
- Use on-site analysis as “gold standard” for validation efforts?

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ESTCP Peer Reviewers
DoD Facility Project Managers