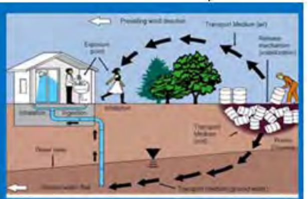
NEWMOA
NORTHEAST WASTE MANAGEMENT OFFICIALS' ASSOCIATION



Technical Training for Waste Site Cleanup Professionals

Vapor Intrusion Assessment:
Guidelines, Data Collection Methods, and Advancements

Presented by:
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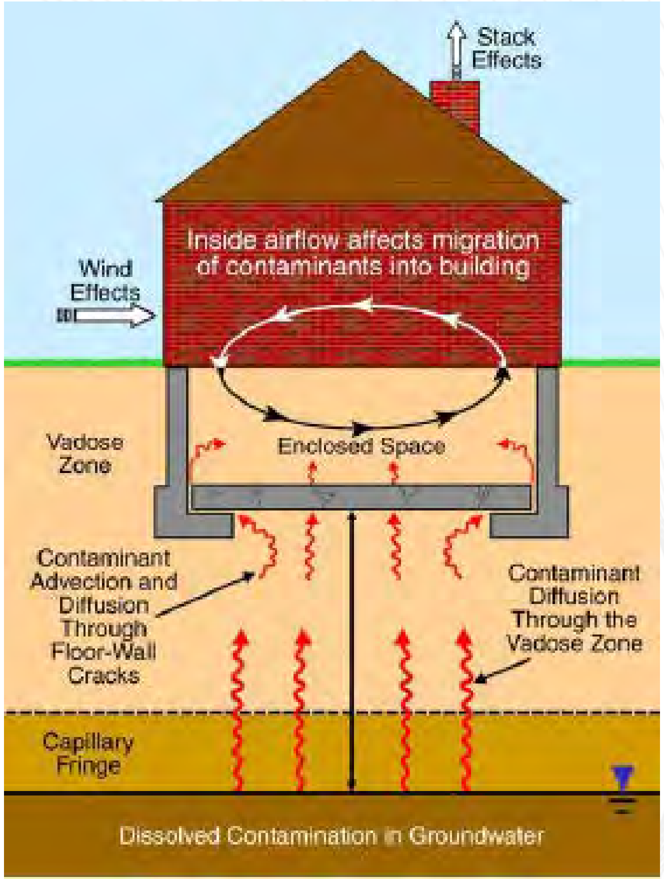
Topics:

- Conventional sampling methods and QA/QC
  - Soil gas
  - Subslab gas
  - Indoor air

- Methods/tools to address uncertainties
  - Real-time field screening
  - Building pressure testing
  - Longer-term samples
  - Guided sampling



ITRC (2014)

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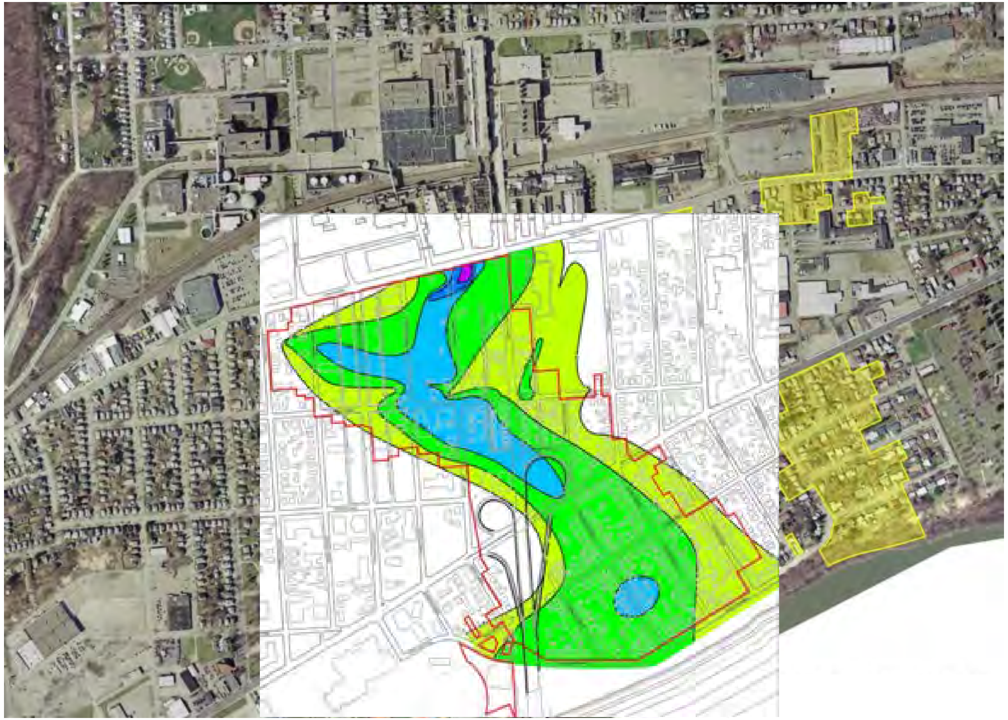
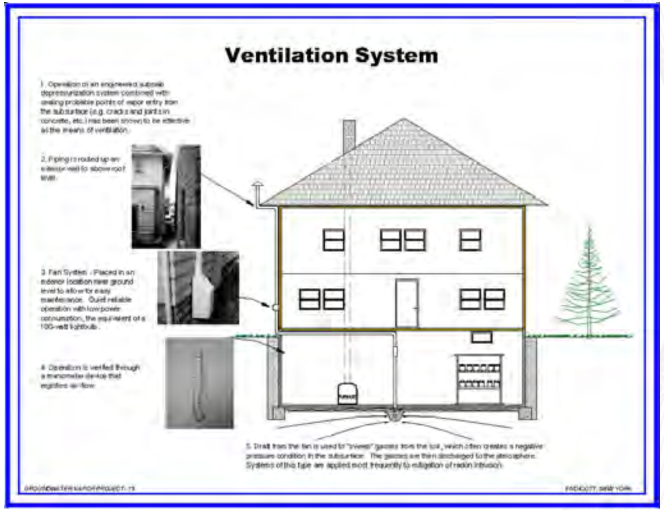
Vapor Intrusion from TCE Plume, Endicott, NY



- One of the largest vapor intrusion sites in the US
- Nearly 1000 properties assessed over a 350-acre TCE plume in groundwater
- Implemented high quality technical methods that advanced the state of practice
- Successful mitigation of over 450 homes and businesses



Investigation Sampling Methods

- Exterior soil gas – temporary and permanent probes
- Subslab vapor – temporary and permanent ports
- Indoor Air

Exterior soil gas sampling

Pros

- Delineate VOCs in soil gas to narrow focus of buildings needing subslab and/or indoor air sampling
- Less disruptive than interior sampling
- Can be done concurrent with soil sampling and logging to identify factors that promote or hinder VI (soil type, layering, moisture content)

Cons

- Subslab vapor favored by most states for comparison to screening levels and indoor air samples
- Potential spatial and temporal variability, particularly for shallower exterior soil gas
- May miss exterior preferential pathways such as utility trenches and sewer lines.

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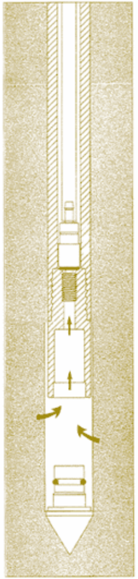
Exterior soil gas sampling probe – single event equipment

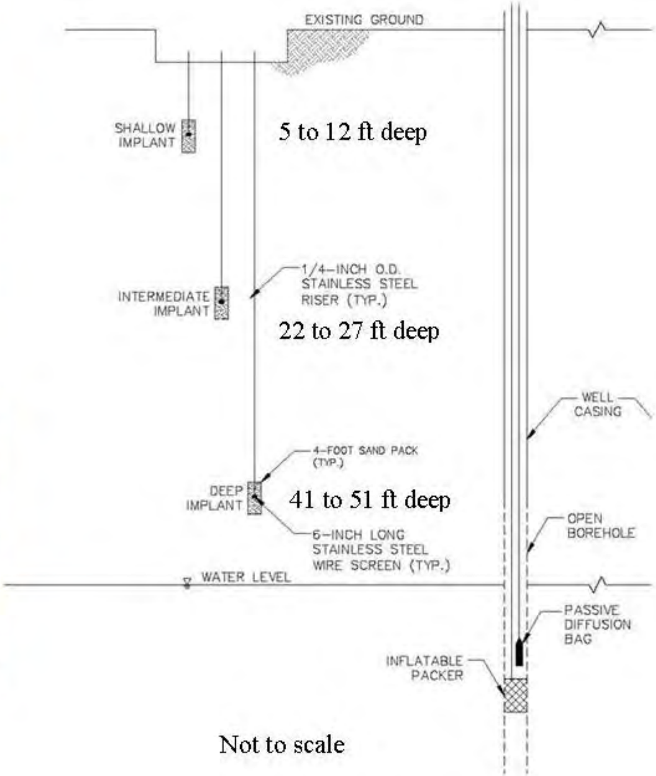


Retractable drive point connect to flexible tubing through hollow rod

Hand-driven tools

Hydraulic push tools

Exterior soil gas sampling probe – permanent monitoring



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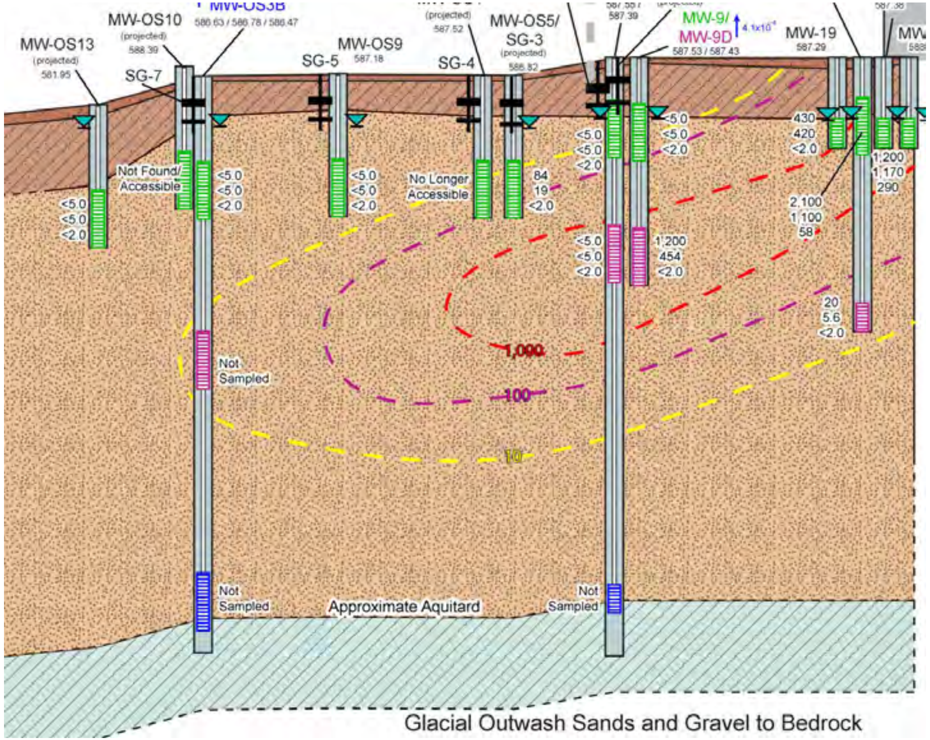
Example of exterior investigation to rule out off-site VI



Multiple physical and chemical lines of evidence:

- Downward hydraulic gradients
- VOC profiling consistent w “diving plume” overlain by clean water lens
- Shallow silt- and clay-rich soils with high water saturation
- TCE not detected in subsurface gas

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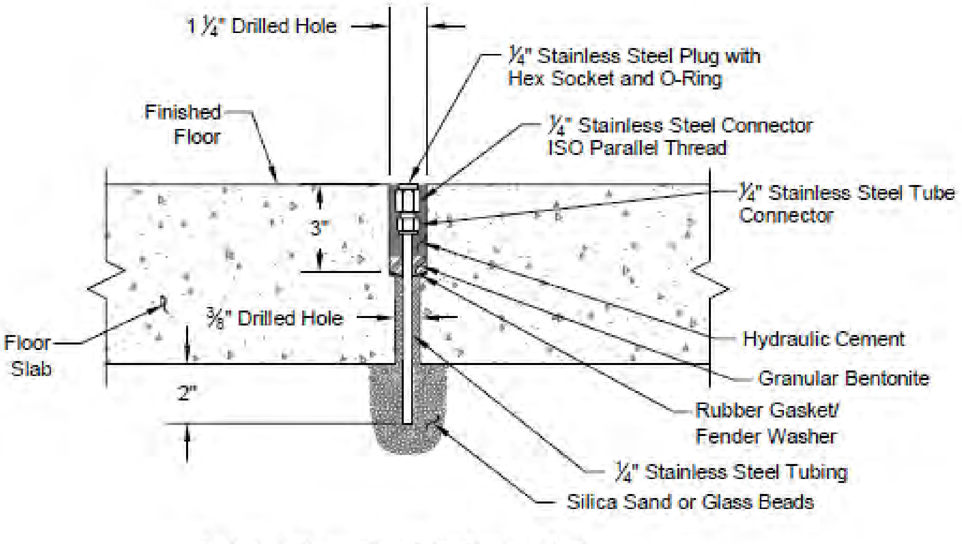
Subslab sampling – single event

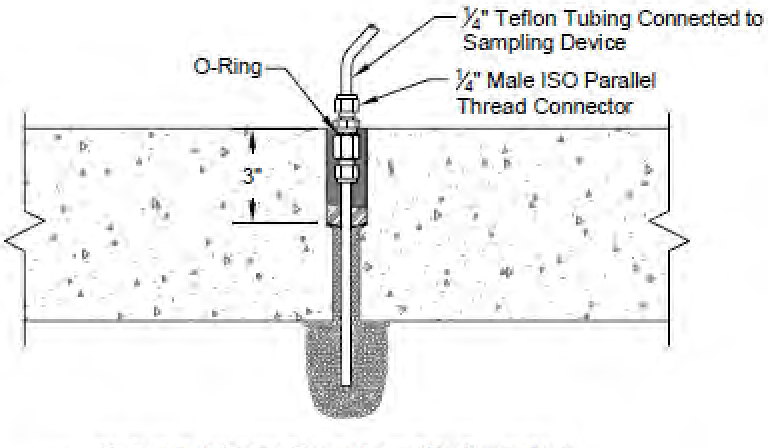
Temporary hole drilled through slab
and sealed with hot beeswax

Subslab Sampling Port – permanent installation used for:

- Multiple sampling events
- Cross-slab differential pressure monitoring to assess VI mitigation performance

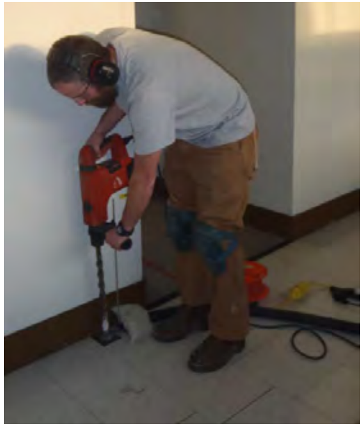


Subslab Sampling/Monitoring Port



Subslab Vapor Sampling Configuration

Subslab port installation

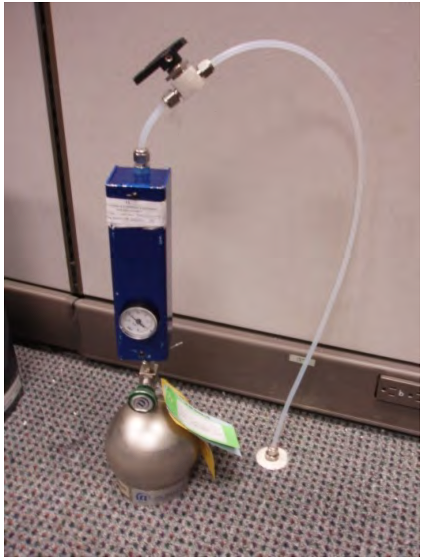


Commercial product

VaporPin®

https://www.vaporpin.com/

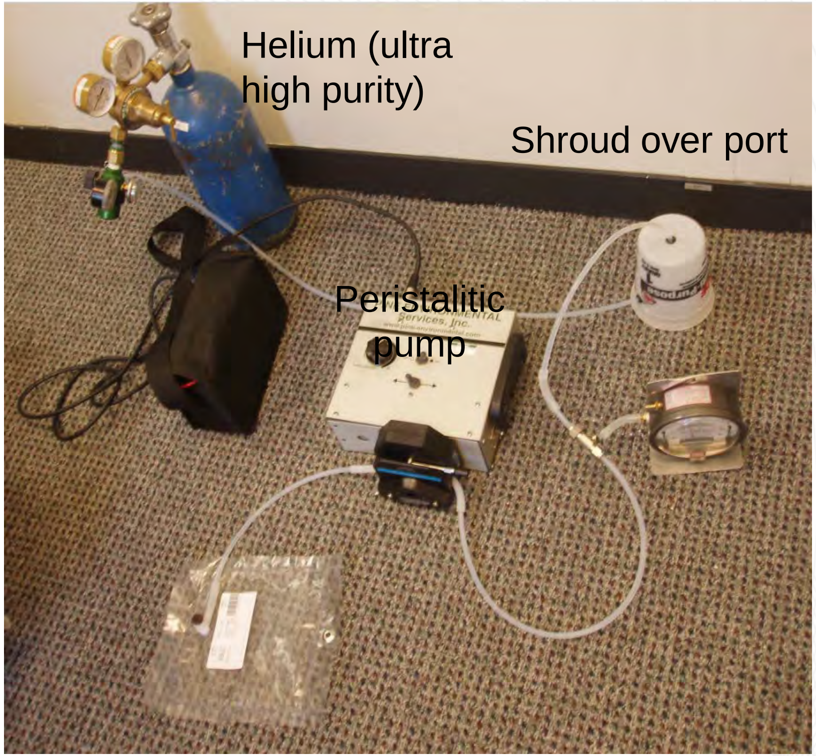
Subslab sampling



Sampling into Summa canister

Collection of primary and field duplicate samples

Integrity/leak testing of port construction



Tedlar bag for screening for helium

How many subslab samples?

State	# of subslab samples for typical residence
Mass	2 to 4, including one from the center; 1 to 2 events
NH	3, including one from the center
NJ	Minimum of 2

For larger residential or commercial/industrial buildings

Table 3-2
Recommended Minimum Number of Sub-Slab Soil Gas Samples

Square footage of building footprint	Number of SSSG Samples
Up to 1,500	2
1,501 to 5,000	3
5,001 to 10,000	4
10,001 to 20,000	5
20,001 to 50,000	6
50,001 to 250,000	8
250,001 to 1,000,000	10
>1,000,000	12+

NJDEP VI Guidance, 2018

"cannot be based on area alone…based on professional judgment to determine the number of subslab samples"

Subslab and soil gas sampling

Sources of Error or Bias	QA/QC Measures	Lessons Learned
Sample dilution due to leaky surface seal drawing in ambient air	Conduct integrity/tracer testing; maintain sample rate <200 ml/min	Use ultra-high purity helium as tracer; avoid sulfur hexafluoride (SF_6) – greenhouse gas
Sample dilution due to leaky tube fittings/connections	Conduct "shut-in" test (see NJ VI guidance for details)	Use gas-tight fittings (no quick-connect fittings)
VOCs absorb/desorb from tubing material	Use Teflon-lined or stainless steel tubing	Discard flexible tubing after each sample. No Tygon, LDPE, or vinyl tubing
Tedlar bags – bag may contain VOCs; bag allows VOC diffusion in and out over a period of days	Analyze ASAP (< 3 hrs) to avoid VOC loss through bag	Use Tedlar bags for "screening" only; Kynar bags are more robust but not readily available
Summa canister sampling	See separate table on indoor air sampling	

Indoor Air Sampling

Typical State guidelines:

- Conduct pre-sampling survey (see next slide)
- Use stainless steel canisters (Summa) for lab analysis by EPA Method TO-15
- Analyze for full TO-15 analyte list unless there is justification for narrowing list
- 24-hr time-averaged samples (8-hr acceptable for non-residential buildings in most states)
- Collect at least one sample from the likely space where VI may occur (basement or crawl space) and one sample from the lowest living level
- When collecting concurrent subslab samples, collect them after indoor air to avoid potentially cross-contamination to indoor air

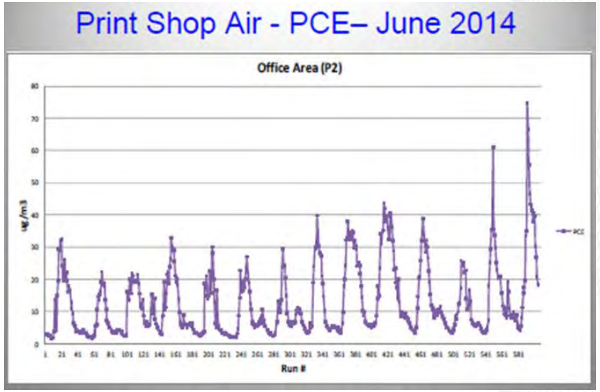
Sampling with Summa canisters

Sources of Error or Bias	QA/QC Measures	Lessons Learned
Contaminated canisters or controllers from lab	Order individually certified clean canisters/controllers and obtain lab QA/QC report	Batch certified canisters not worth the uncertainty in cleanliness
Faulty equipment – low canister vacuum on receipt	Check canister vacuums prior to field mobilization	Order extra canisters
Faulty equipment – flow controllers	Check canister vacuum frequently during sampling	Order extra controllers
Field contamination during prep/storage/shipping	Collect field blank using ultra high purity nitrogen	Order UHP nitrogen from lab – commercial gas may have trace contaminants
Leakage during return shipping	Close canister with 7 to 3 in. Hg vacuum remaining and record on Chain-of-Custody	Don't rely on canister gauge – use separate vacuum gauge
Field imprecision	Collect a field duplicate sample	Collect duplicate where you expect to get a VOC detection

The major confounding factors of indoor air sampling:

1. Background/indoor sources of VOCs

2. Time variability of VI



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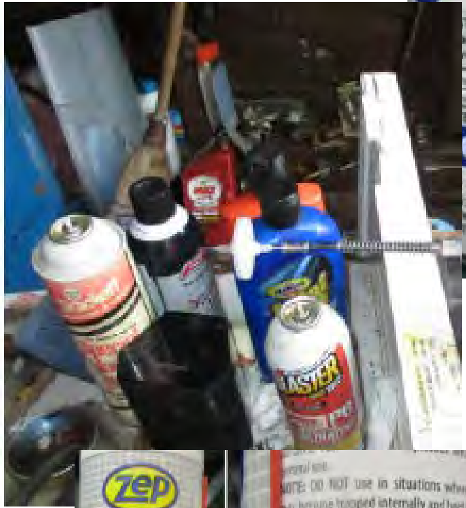
Hartman et al, AEHS San Diego, March 2018

Examples of PCE- and TCE-containing products that can interfere with VI sampling



Indoor Air Sampling – Beware of indoor sources

Indoor sources of VOCs

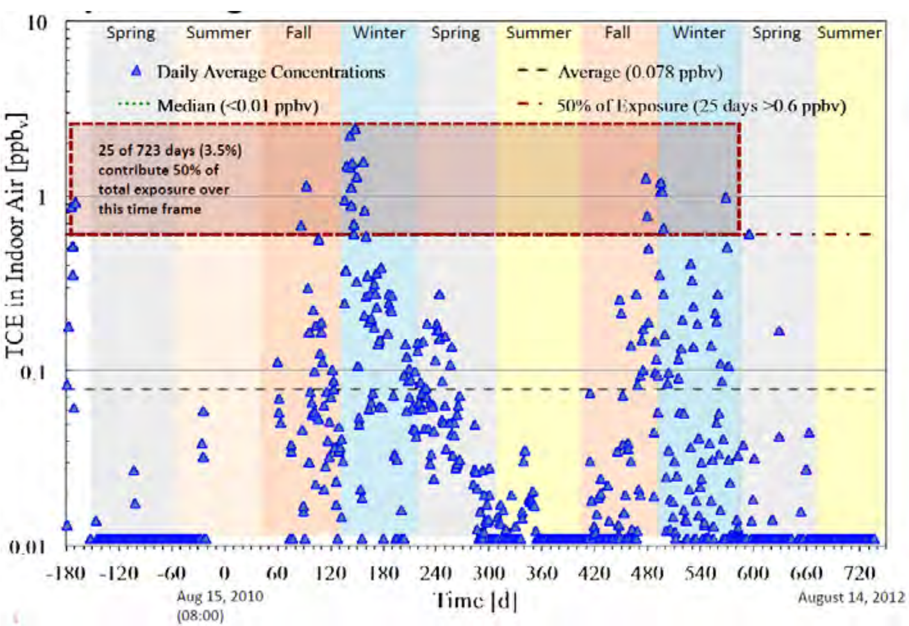
- Household and commercial products
- Dry-cleaned clothes
- Building materials (paints, finishes, carpets, adhesives, etc.)
- Former chemical use absorbed in building walls and floors
- VOCs entering from outdoor air

QA/QC Measures

- Conduct pre-sampling survey including field documentation and photos
- Remove commercial products 24 to 48 hrs before sampling – not always feasible
- Collect outdoor air sample upwind of building or near HVAC intake
- Collect subslab samples for comparison

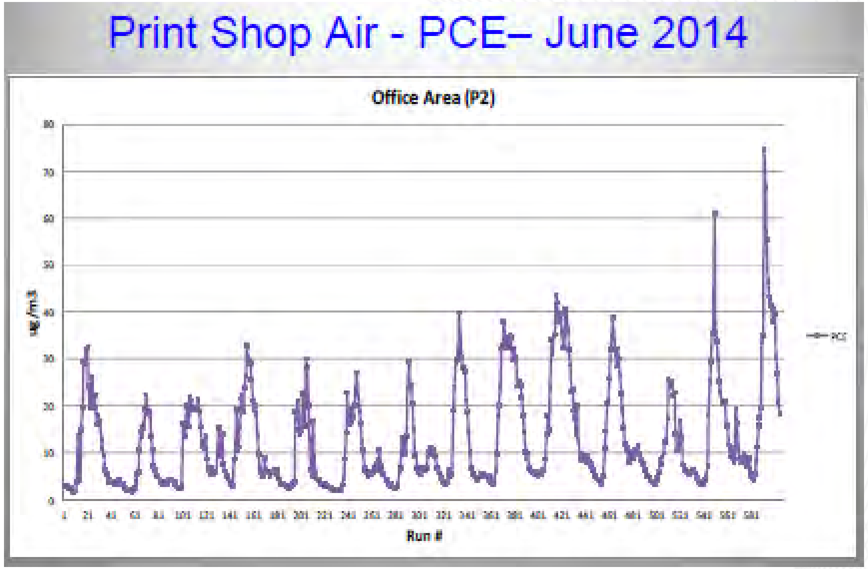
Vapor intrusion can be extremely time variable

A 24-hr sample represents neither the worst-case short-term nor the long-term average



Arizona State U. Research House, Layton, UT

Holton et al., ES&T, 2013, 47, 13347-13354



Hartman et al, AEHS San Diego, March 2018

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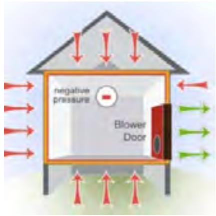
How many indoor air sampling events?

State	Guidance
Maine	4 successive "clean" rounds spaced 3 mos. apart to conclude no VI pathway
Mass	Multiple rounds across several seasons, including worst-case (Tbl 2 of VI guidance); At least 2 to 4 rounds to conclude no VI pathway
NH	1 round in late winter/early spring
NJ	1 round in the heating season (Nov 1 to Mar 31) assuming no other contradictory lines of evidence
NY	Multiple rounds across several heating seasons

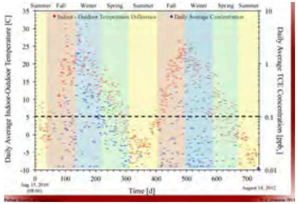
Methods/tools to address indoor sources and variability

1. Real-time screening and continuous monitoring



2. Building pressure tests

3. Longer-term samples



4. Guided samples (by temperature, radon, other parameters)

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Real-time VI assessment with portable analyzer

- 100,000 sq. ft. footprint
- TCE used in 1960s and 1970s
- Subsurface TCE presence indentified in 1990s
- Groundwater at depth of ~5 feet below slab

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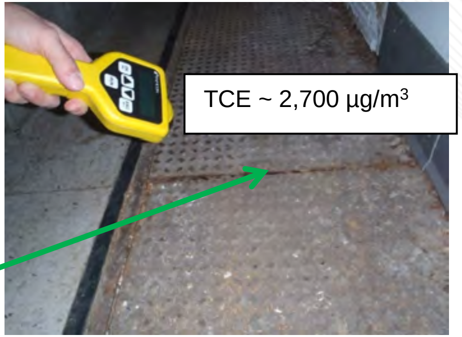
Real-time VI assessment with portable analyzer

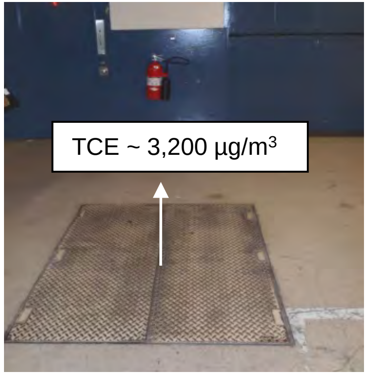
- 62 samples during 2 days with portable GC/MS
- TCE ranged from 15 to 690 ug/m^3 (median of 71)

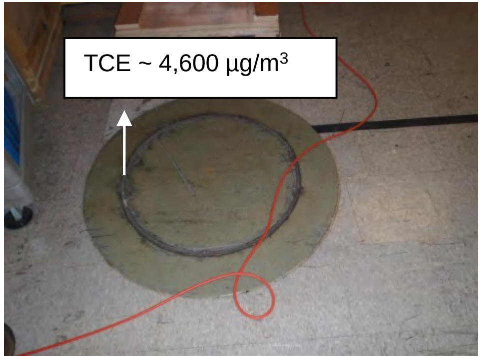
Identifying the vapor entry pathways:

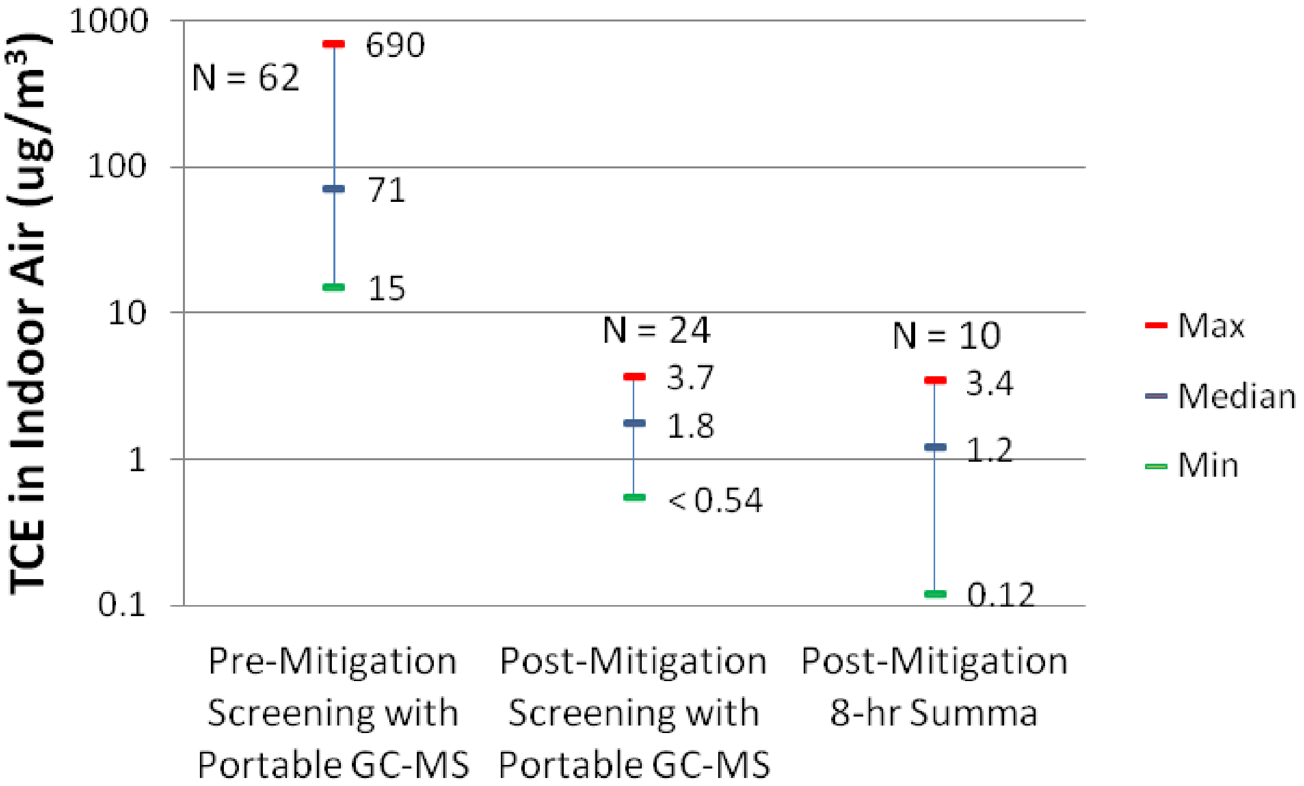
Air handler unit mechanical rooms under negative pressure



Targeted screening of interior storm drain manholes







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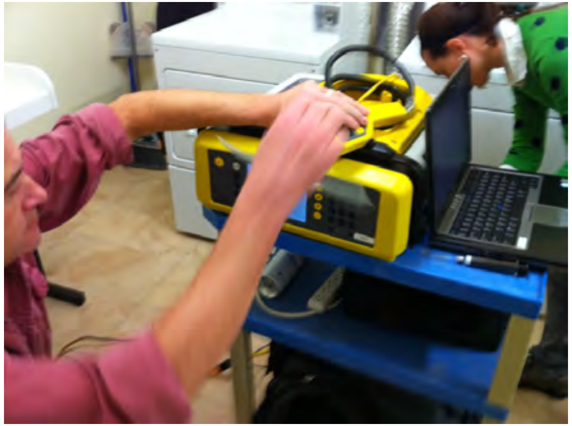
PCE and TCE in indoor air in former mill building converted to apartments (artistic residences) → Is it VI or indoor sources of chemicals?



Instant results using portable analyzer (HAPSITE)

Sniffing for VI from cracks under rugs

- Analyzed ~80 samples over 2 days in 25 apartments
- Analyzed household products, art supplies, and potential VI pathways

Results:
PCE due to art supplies.
TCE due to VI through floor cracks.

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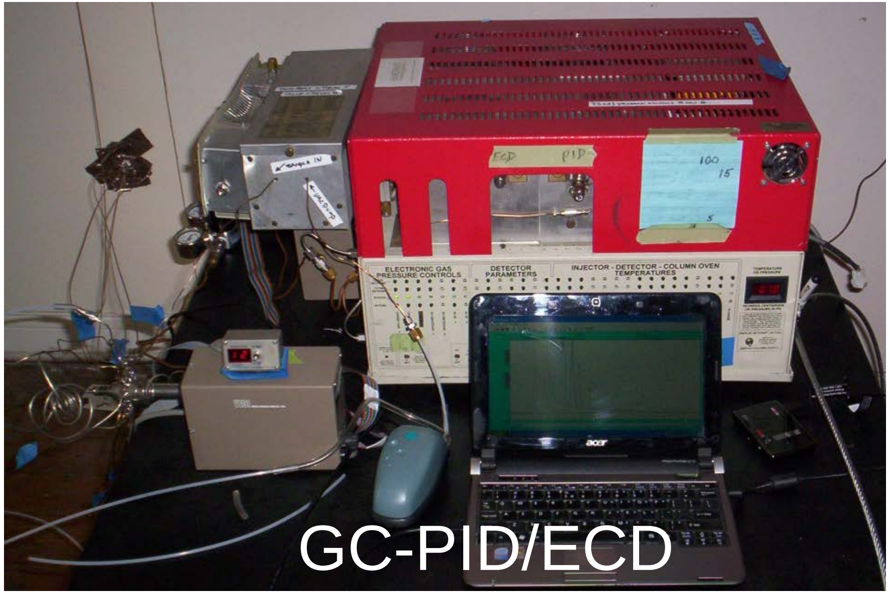
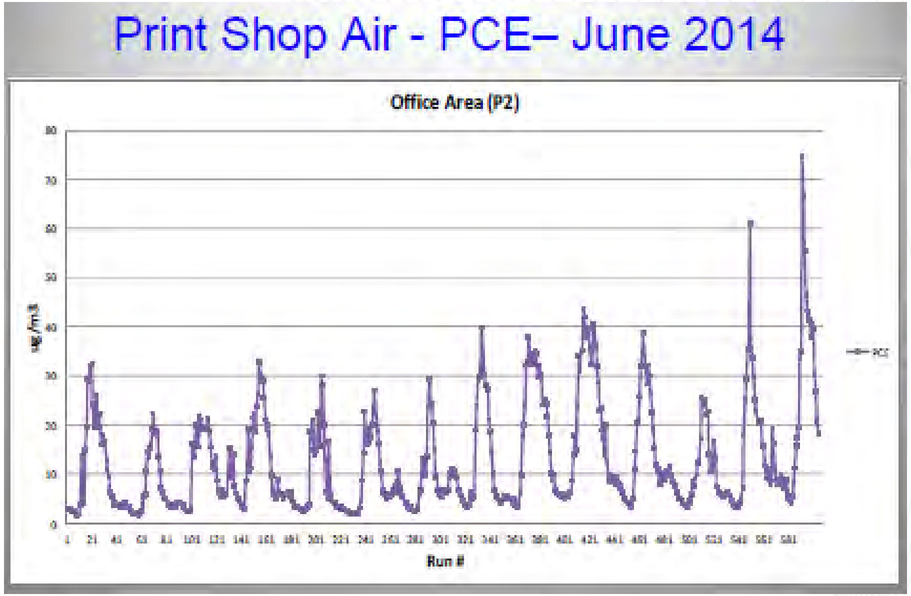
Courtesy of StoneHill Environmental

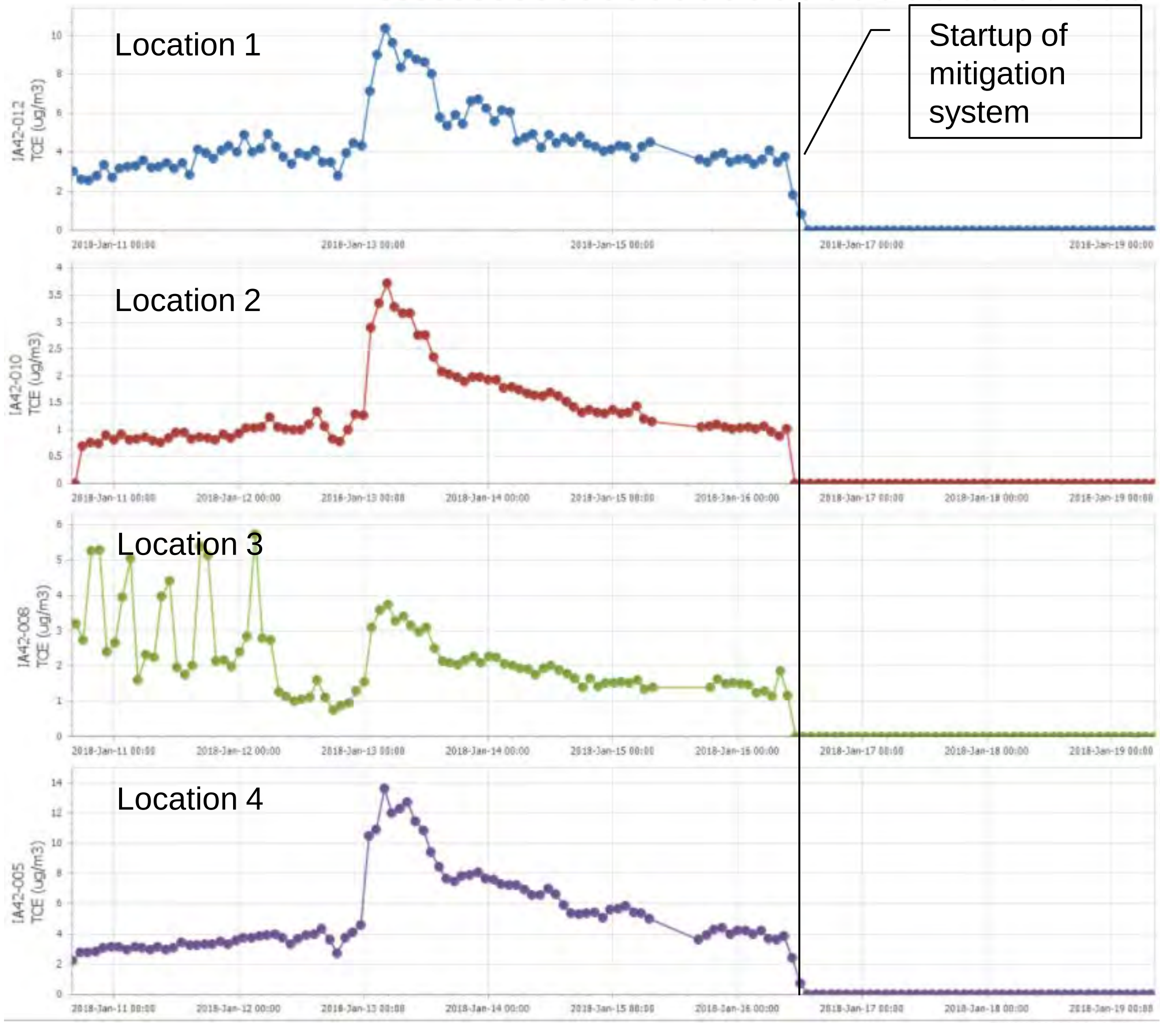
Continuous real-time air monitoring





PCE increases every night when the HVAC system is off

Continuous indoor air monitoring



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Advantages of real-time and continuous data

- No waiting 2 weeks or more for lab results
- Lots of data offers opportunity to identify variability and patterns
- Distinguish VI from indoor chemicals
- Find VI entry locations/pathways
- Informs best mitigation strategy
- Immediately evaluate mitigation effectiveness

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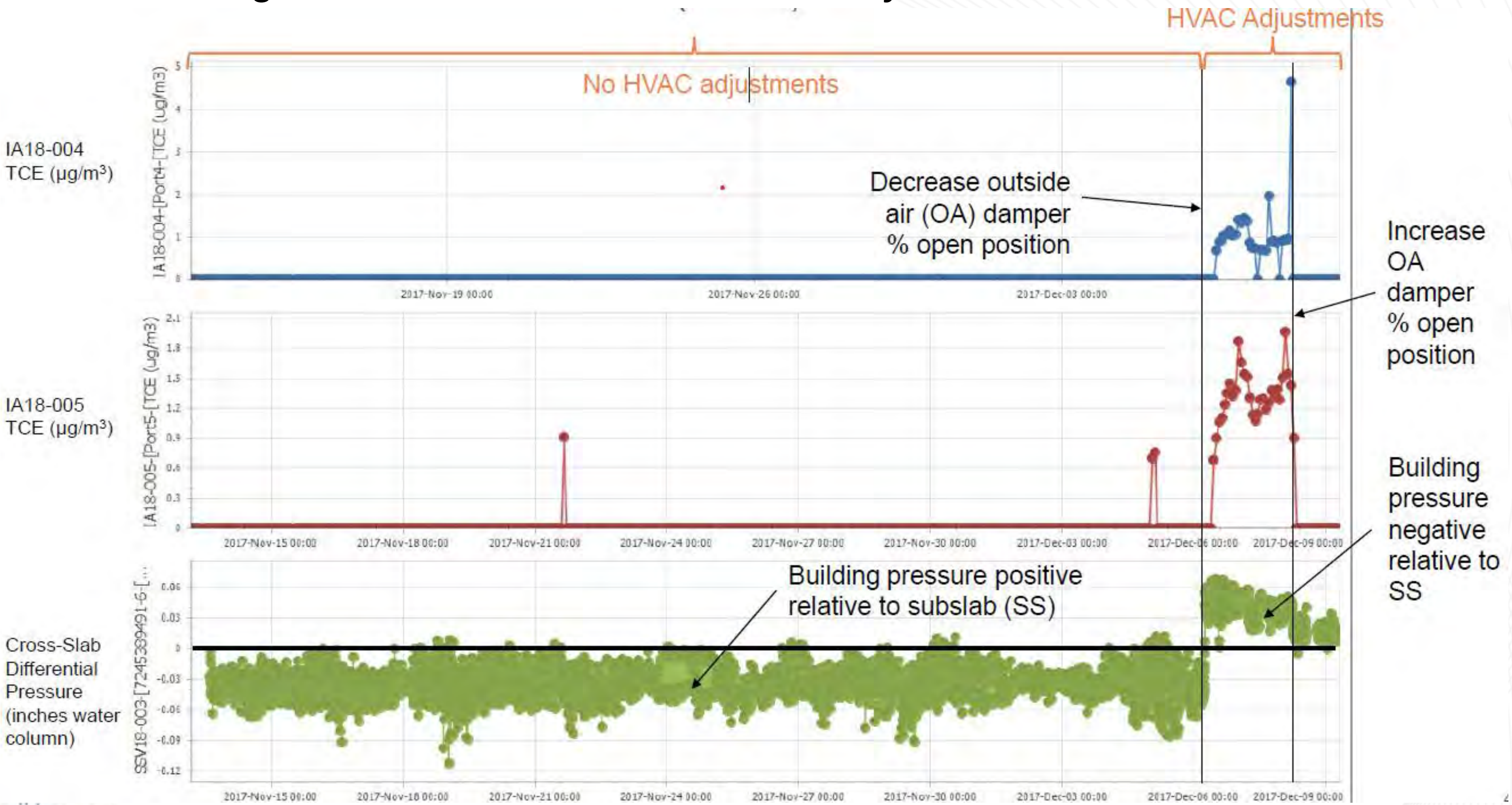
Real-time Monitoring of HVAC Performance Reliability



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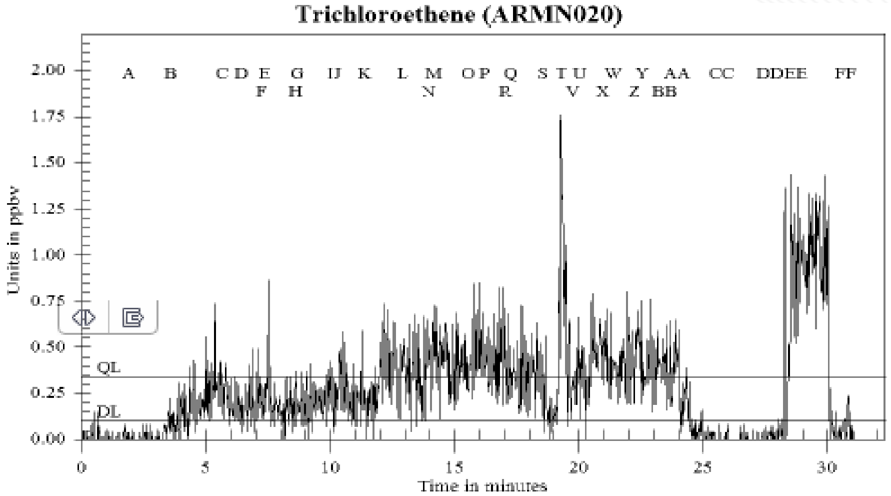
Real-time continuous VI sampling using EPA's Trace Atmospheric Gas Analyzer (TAGA) Mobile Laboratories



For more information:

Archive of Aug 29, 2018 webinar: https://clu-in.org/live/archive/

Contact: David Mickunas, US EPA, Environmental Response Team
(919) 541-4191
mickunas.dave@epa.gov

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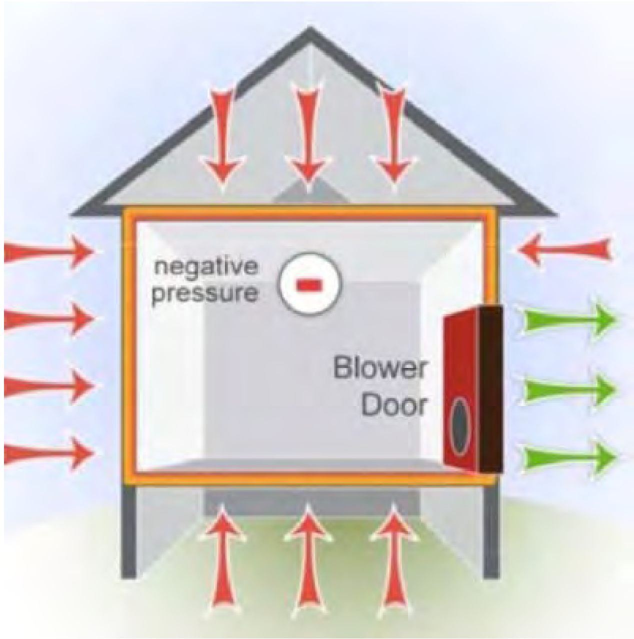
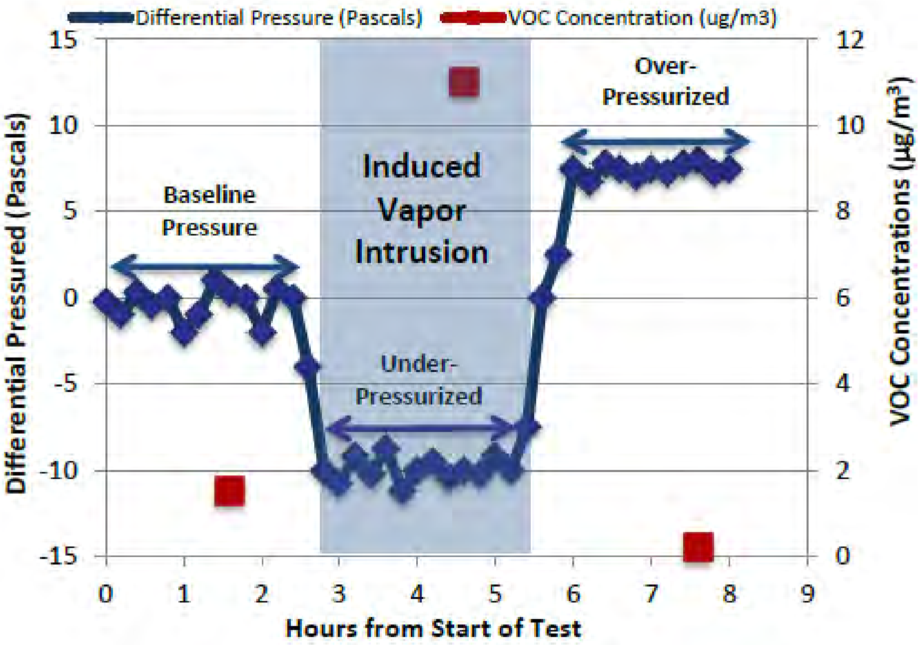
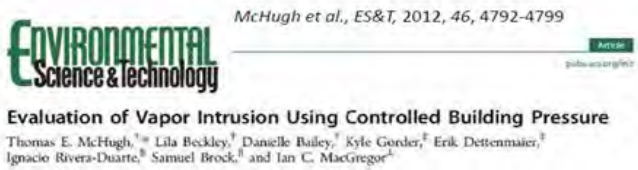
VI Diagnostic Tool: Building Pressure Tests





Negative pressure: favors VI
Positive pressure: suppresses VI

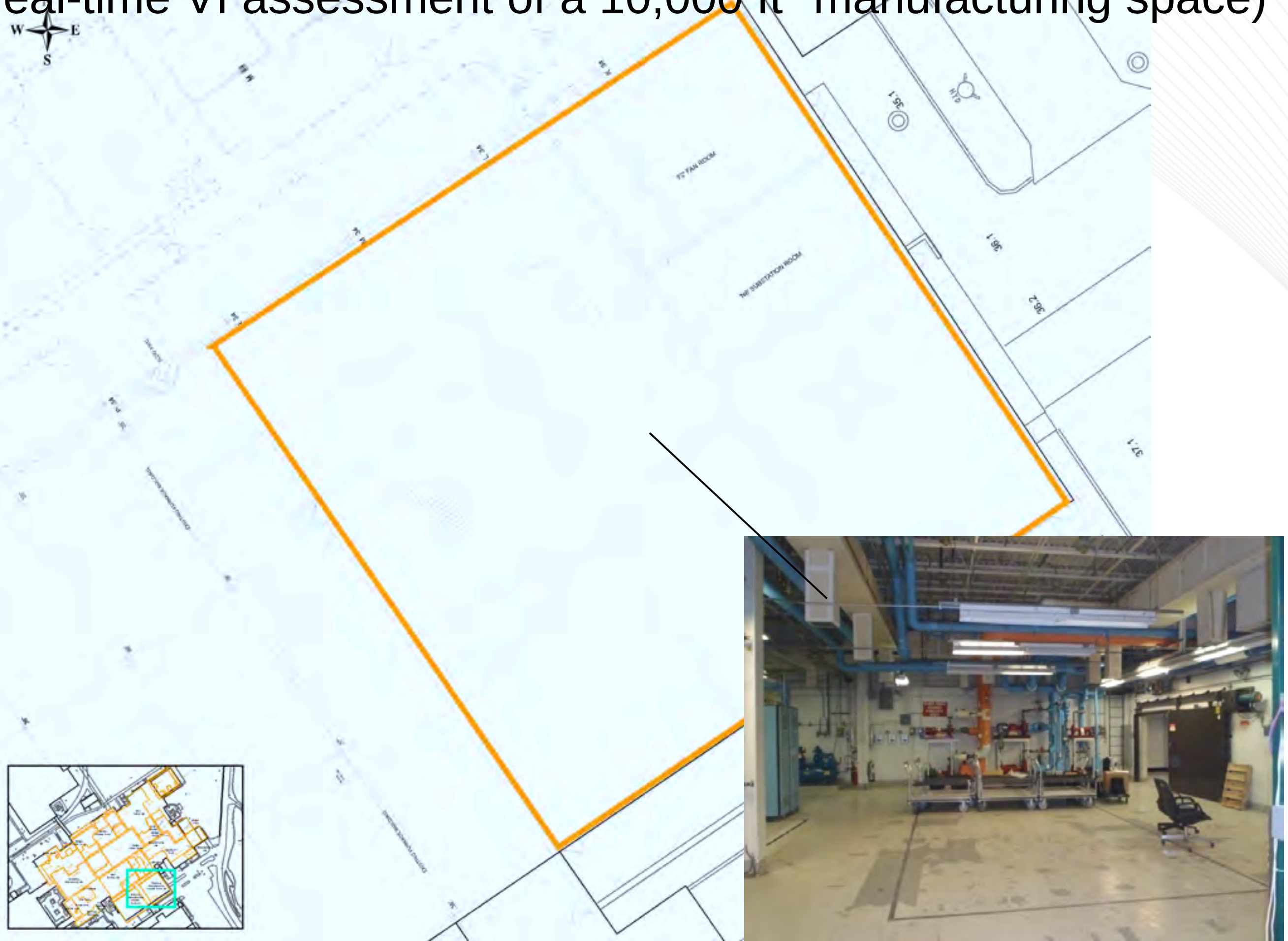

McHugh et al., ES&T, 2012, 46, 4792-4799

Environmental Science & Technology

Evaluation of Vapor Intrusion Using Controlled Building Pressure

Thomas E. McHugh, Lila Beckley, Danielle Bailey, Kyle Gorder, Erik Dettenmaier, Ignacio Rivera-Duarte, Samuel Brock, and Ian C. MacGregor

Building pressure manipulation for an industrial building (real-time VI assessment of a 10,000 ft^2 manufacturing space)



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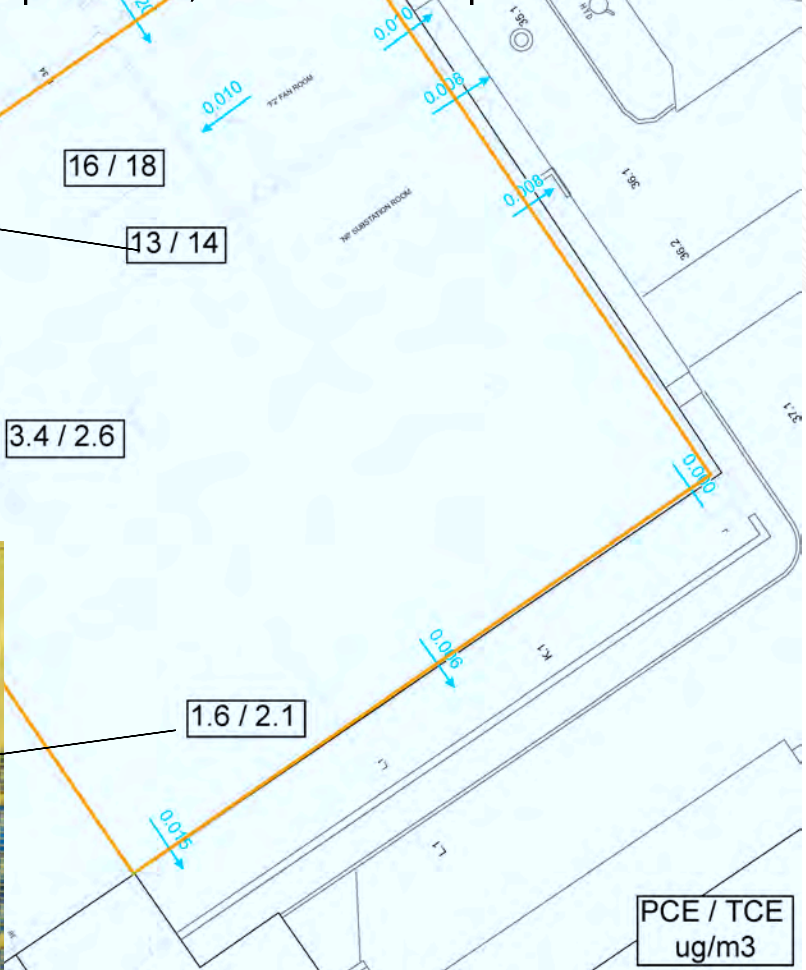
Initial conditions

Normal HVAC operations, room ~neutral pressure



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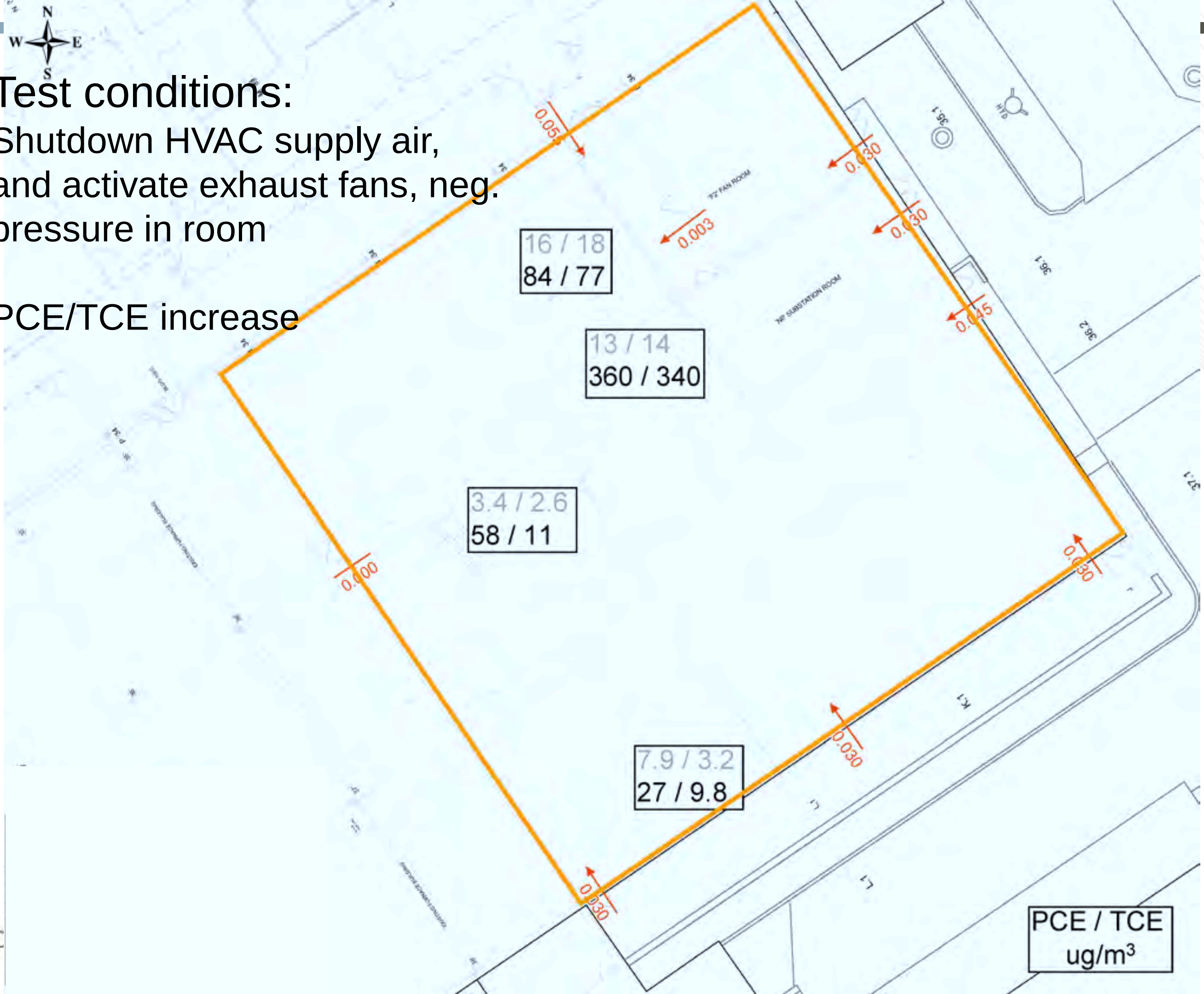
Test conditions:

Shutdown HVAC supply air, and activate exhaust fans, neg. pressure in room

PCE/TCE increase



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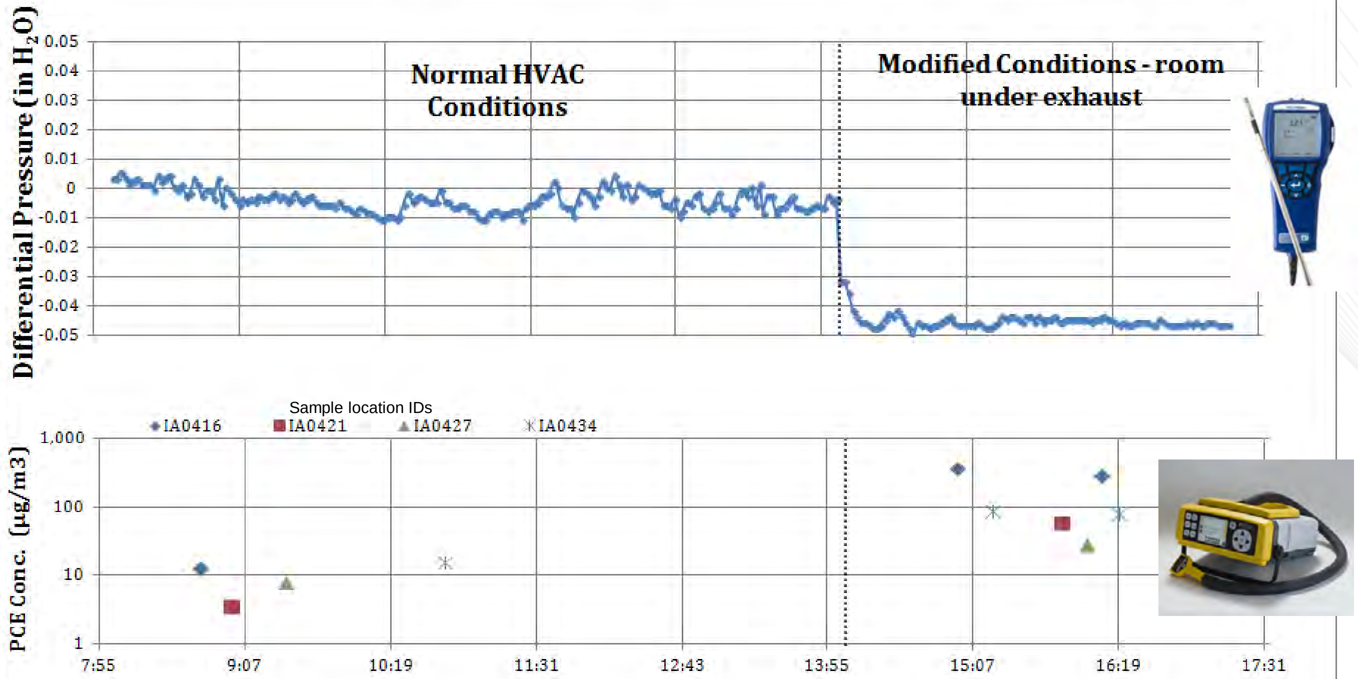
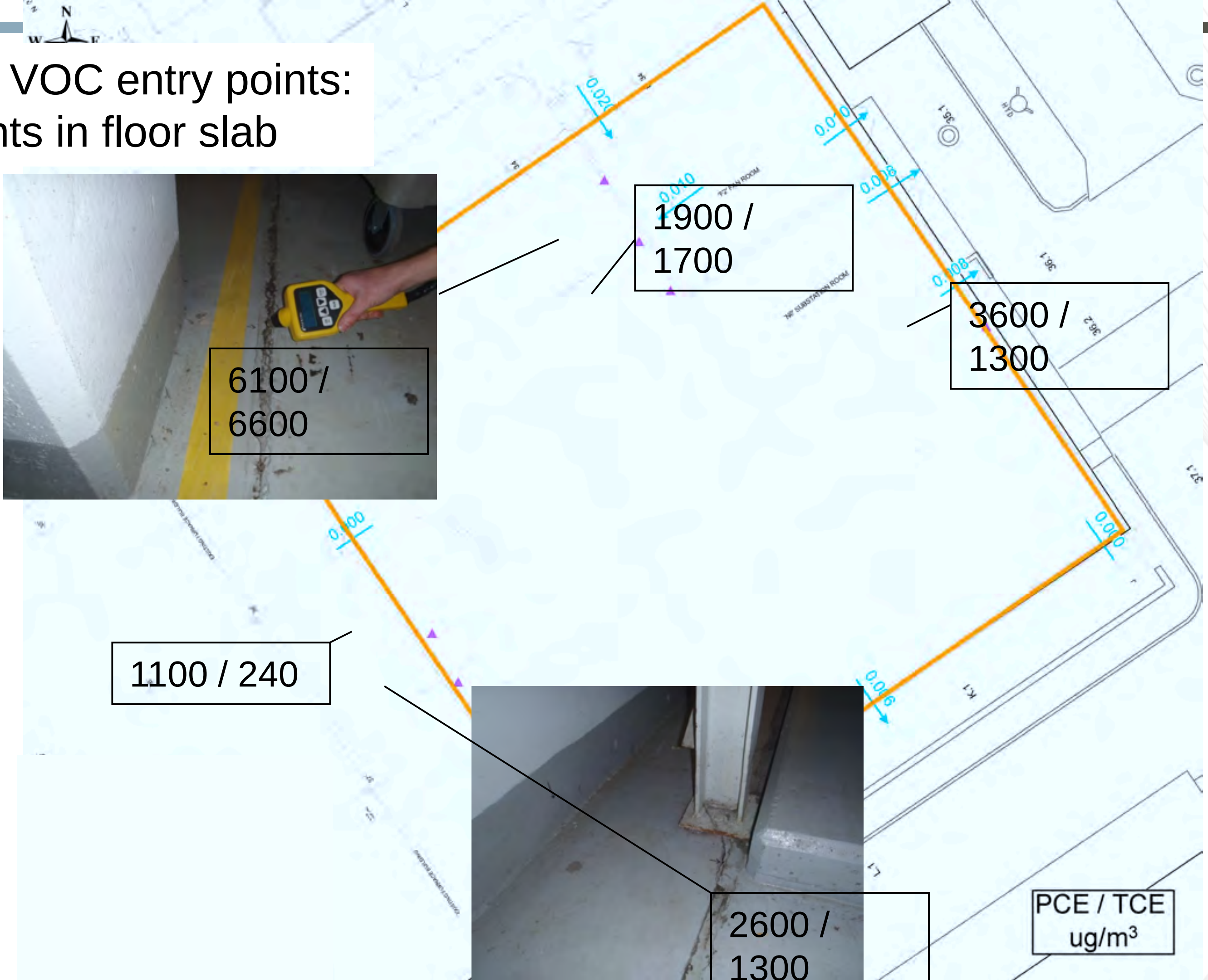


Response of indoor VOC levels to change in room pressure: negative pressure = higher VOC levels

Identifying the VOC entry points: Expansion joints in floor slab



In 1 day of real-time assessment:

- Obtained and analyzed 27 samples using the portable GC-MS
- Established baseline indoor air VOC conditions
- Without sub-slab sampling, confirmed that baseline conditions were due to vapor intrusion, not background levels
- Identified the VOC entry pathways (i.e. the expansion joints), which suggested a remedial solution (re-caulking/sealing the joints)

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Hypothetical Cost Comparison*: VI assessment of 20,000 sq ft building

Conventional						Portable GC-MS				
Description	Qty	Unit Cost	Units	Cost		Description	Qty	Unit Cost	Units	Cost
Baseline Sampling						Baseline and Focused Sampling				
Indoor Air (TO-15)	5	$450	sample	$2,250		GC-MS Calibration	1	$900	lump	$900
Sub-slab (TO-15)	5	$450	sample	$2,250		GC-MS	1	$500	day	$500
Labor	4	$1,200	person-days	$4,800		Labor	2	$1,200	person-days	$2,400
						Confirmatory (TO-15)	5	$450	sample	$2,250
Focused Follow-up Sampling										
Indoor Air (TO-15)	10	$450	sample	$4,500						
Labor	2	$1,200	person-days	$2,400						
			Total	**$16,200**					Total	**$6,100**

* Cost estimates are for relative comparison and do not include other items likely common to both approaches, such as report preparation, project management, and QA/QC

Long-term Sampling Devices (passive samplers)

Courtesy of Heidi Hayes eurofins | Air Toxics

Waterloo Membrane Sampler

Radiello passive sampler

Pros

- Small, unobtrusive, easy to use, easy to ship
- Total cost typically less than Summa canister samples
- Provide 1-day to 30-day (or more) composite samples that can capture longer term variability

Cons

- Requires careful selection of sampling device, sorbent material, and deployment time to achieve target analyte reporting limits – need to consult with laboratory
- Some VOCs are weakly absorbed and poorly retained (e.g., vinyl chloride, chloromethane)
- May miss short-term concentration peaks/spikes
- Not routinely accepted in place of 24-hr Summa samples for final risk decisions

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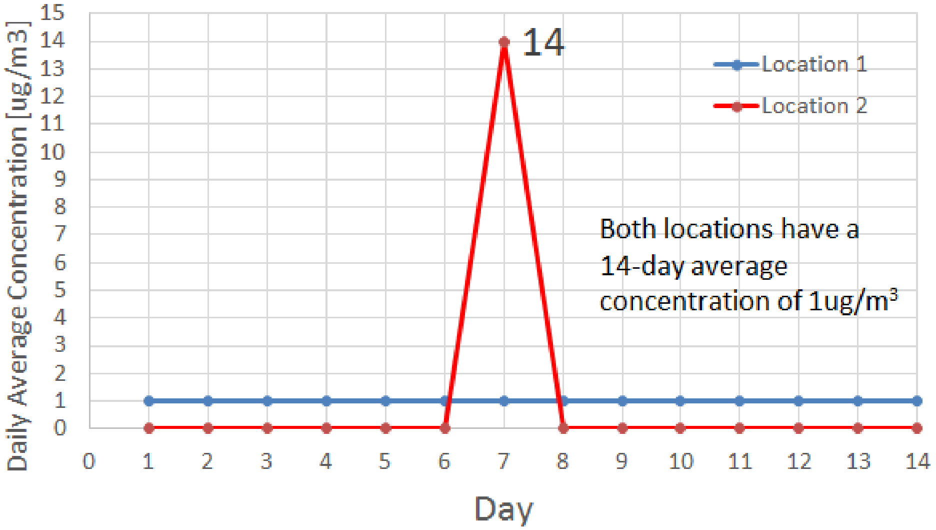
Assessing short-term peaks using long-term sampler results



Max. Daily Avg [ug/m^3] =
(Long-term conc) x (# days of deployment)

For example:
To meet TCE daily max threshold of <6 ug/m^3, then 14-day avg result must be <0.43 ug/m^3

For more information on passive samplers…

EPA United States Environmental Protection Agency

Engineering Issue

Passive Samplers for Investigations of Air Quality: Method Description, Implementation, and Comparison to Alternative Sampling Methods

TABLE OF CONTENTS

The U.S. Environmental Protection Agency (EPA) Engineering Issue Papers (EIPs) are a series of technology transfer documents that summarize the latest available information on selected treatment and site remediation technologies and related issues. EIPs are designed to help remedial project managers, on-scene coordinators, contractors, and other site managers understand the type of data and site characteristics needed to evaluate a technology for potential applicability to their specific sites. Each EIP is developed in conjunction with a small group of scientists inside EPA and with outside consultants and relies on peer-reviewed literature, EPA reports, Web sources, current ongoing research, and other pertinent information. As such, this EIP is a technical support document describing the current state of knowledge on passive sampler application and performance and does not represent EPA policy or guidance.

1 PURPOSE AND SUMMARY

The purpose of this EIP is to summarize the "state of the science" regarding the use of passive air samplers for investigating subsurface vapor intrusion (VI) to indoor air. This Paper covers the basics of passive sampler design, compares passive samplers to conventional methods of air sampling, and discusses considerations when implementing a passive sampling program. The Paper also discusses field sampling and sample analysis considerations to ensure data quality is adequate and interpretations based on the passive sample data are supportable. The reader is expected to have a basic technical background on the VI exposure pathway and how to use and interpret indoor air sampling data in the context of a VI investigation. For guidance and policy on VI assessment and technical support documents, please visit:

ESTCP
Cost and Performance Report
(ER-200830)

Development of More Cost-Effective Methods for Long-Term Monitoring of Soil Vapor Intrusion to Indoor Air Using Quantitative Passive Diffusive-Adsorptive Sampling Techniques

May 2015

ESTCP
ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM
U.S. Department of Defense

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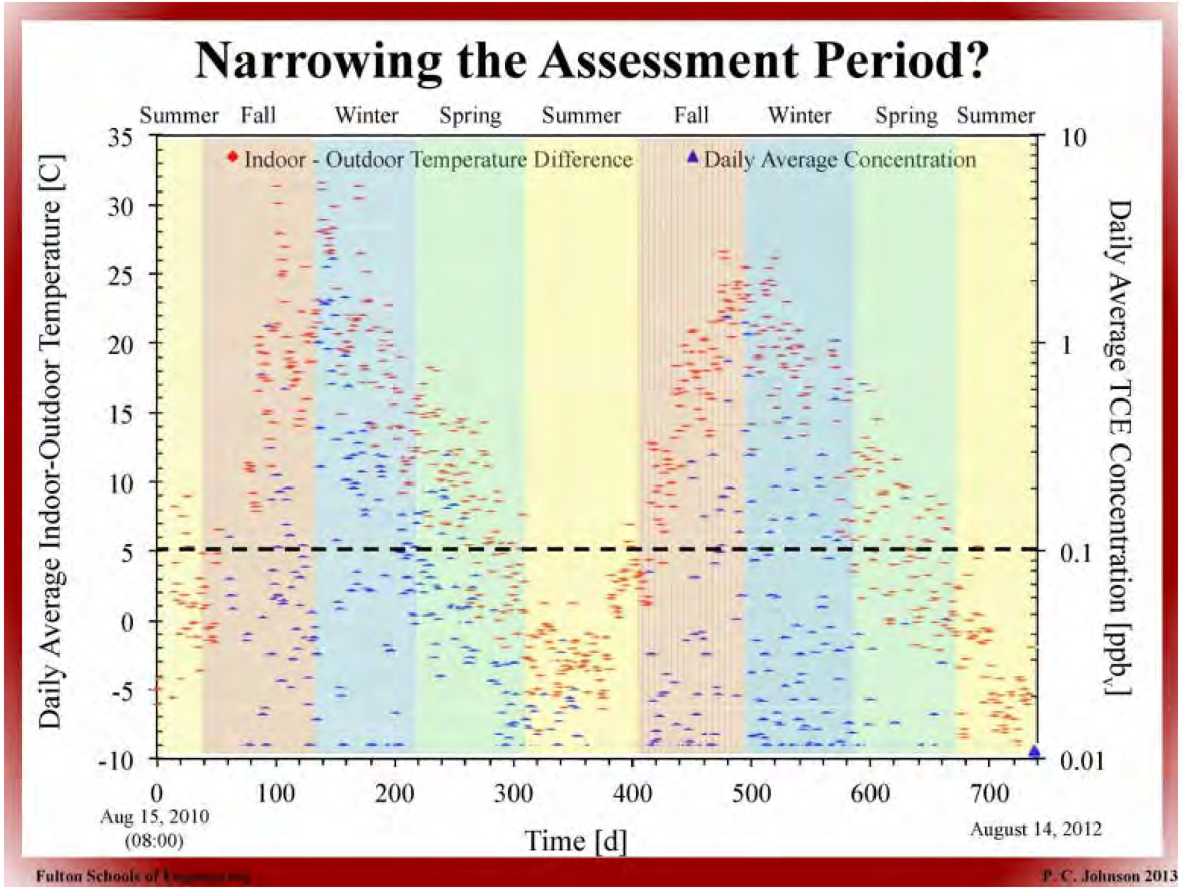
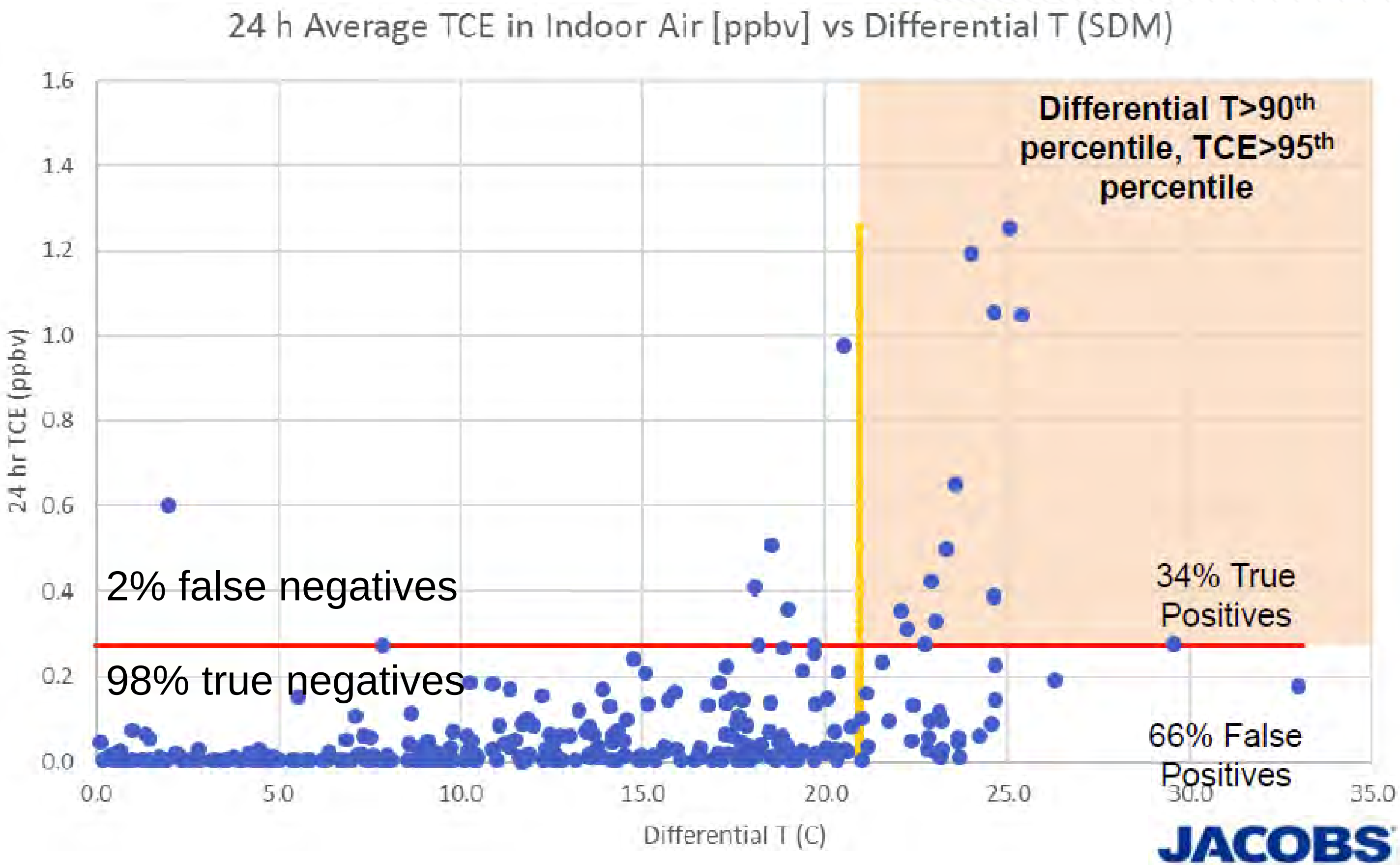
Guided Sampling: Recent US EPA initiative to use indicator parameters such as temperature, pressure, and radon to sample indoor air when worst-case VI is most likely



Sun Devil Manor, UT

Temperature differential as a VI indicator at Sun Devil Manor, UT



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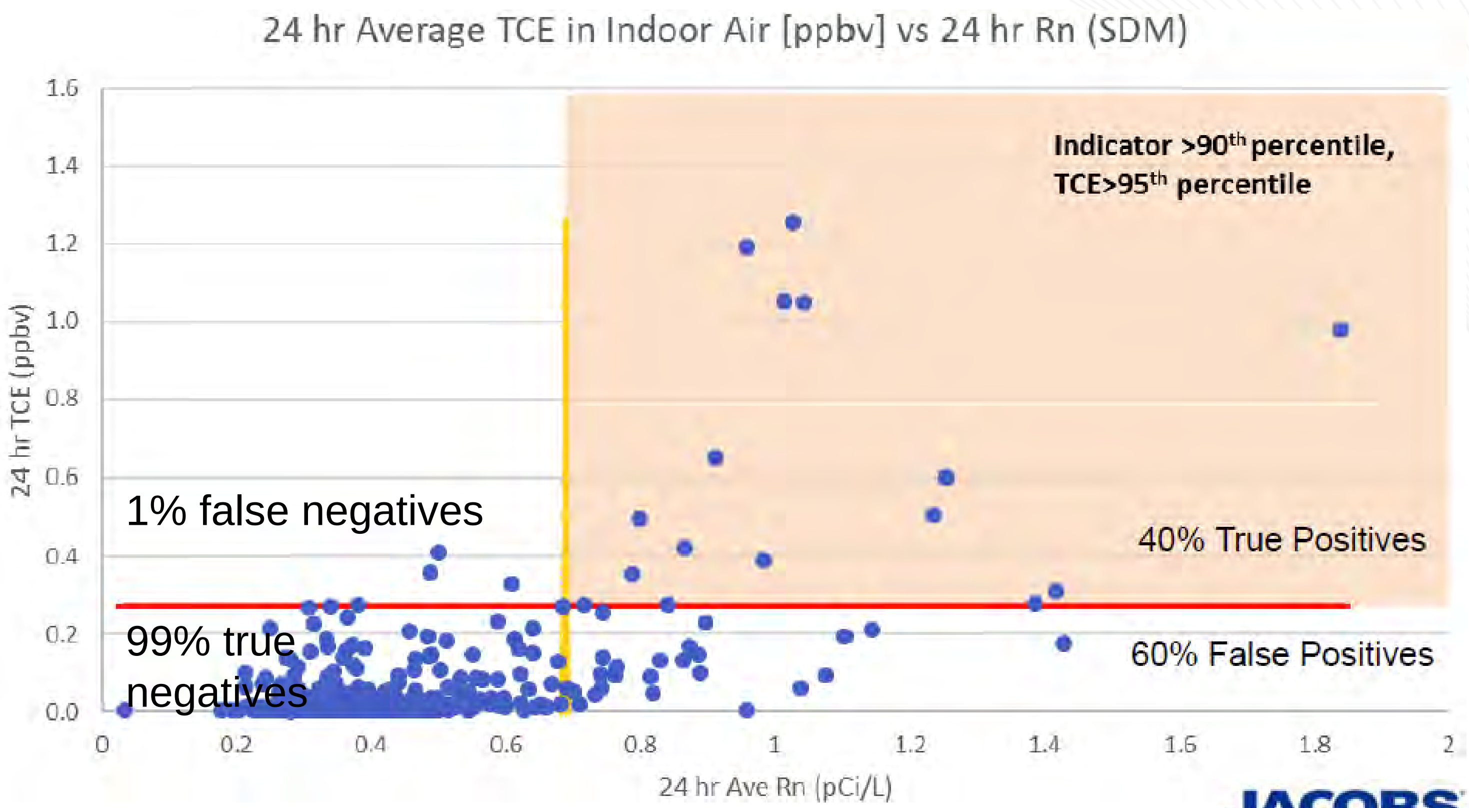
Radon as a VI indicator at Sun Devil Manor, UT



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Guided sampling: preliminary findings based on a few structures

- Highly confident "negative" predictive value of temperature differential and radon – sampling for VI when these parameters are not "elevated" will not likely (>95% confidence) reveal short-term, worst-case VI

- Conversely, sampling when these parameters are "elevated" is more likely to find "elevated" VOC levels from VI (30-40% positive predictive value)

- This approach requires real-time monitoring of ΔT and radon levels to select conditions favorable for sampling to capture short-term, worst-case VI

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Wrap-up Messages

- Conventional VI sampling methods are well-established, but hindered by their “snapshot” nature and prone to error/bias (e.g. missing variability, indoor/background VOC sources)

- Tools and methods are available to reduce uncertainty inherent in conventional VI assessments:
  - Real-time and continuous field screening
  - Building pressure testing coupled with field screening/sampling
  - Long-term sampling

- Active research area: given the temporal variability in VI, can we use guided sampling to capture reasonable maximum exposure? Stay tuned…

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