NEWMOA
NORTHEAST WASTE MANAGEMENT OFFICIALS' ASSOCIATION

Vapor Intrusion:
Residential Investigation & Mitigation

January 16, 2024

Presented by:
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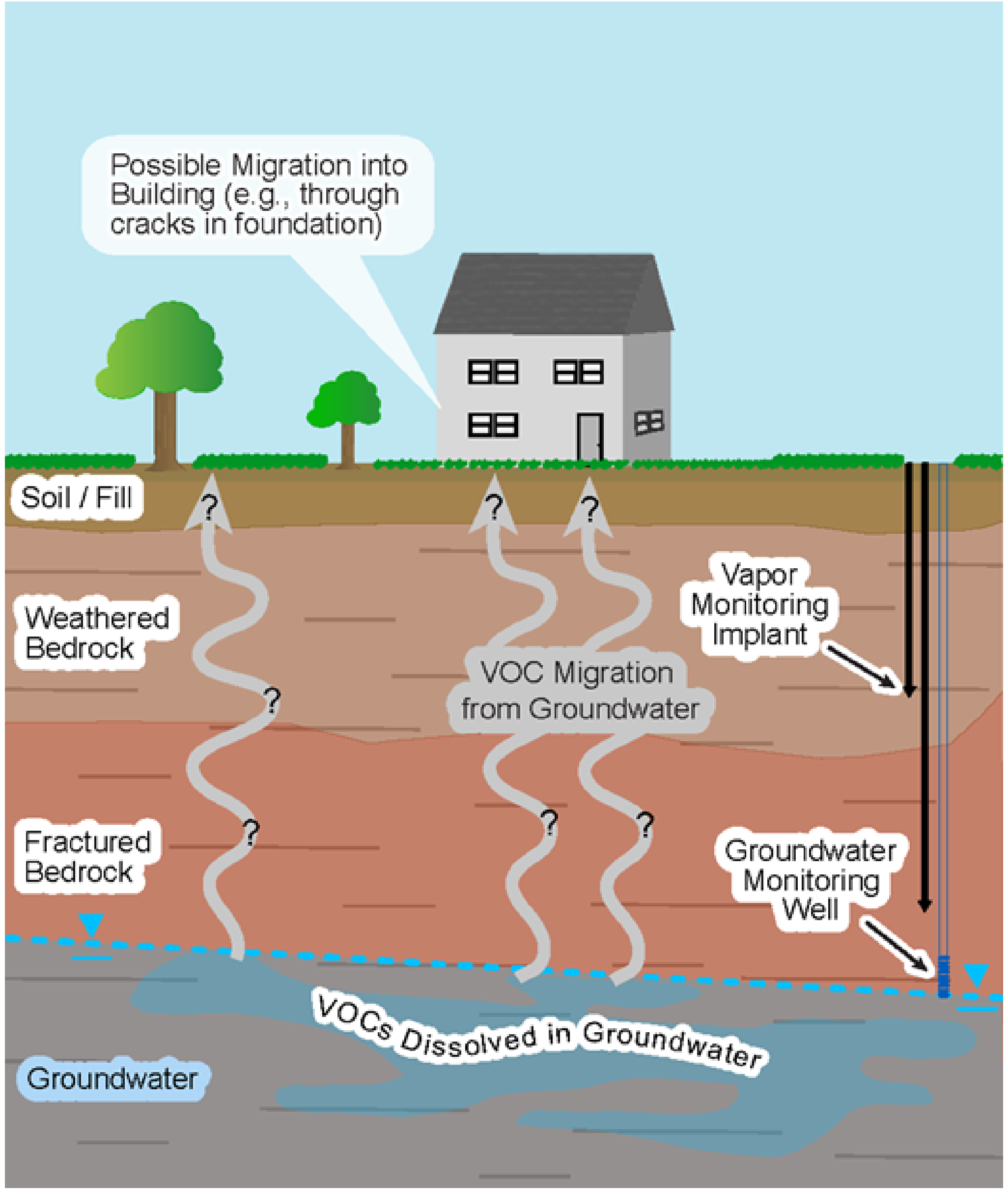

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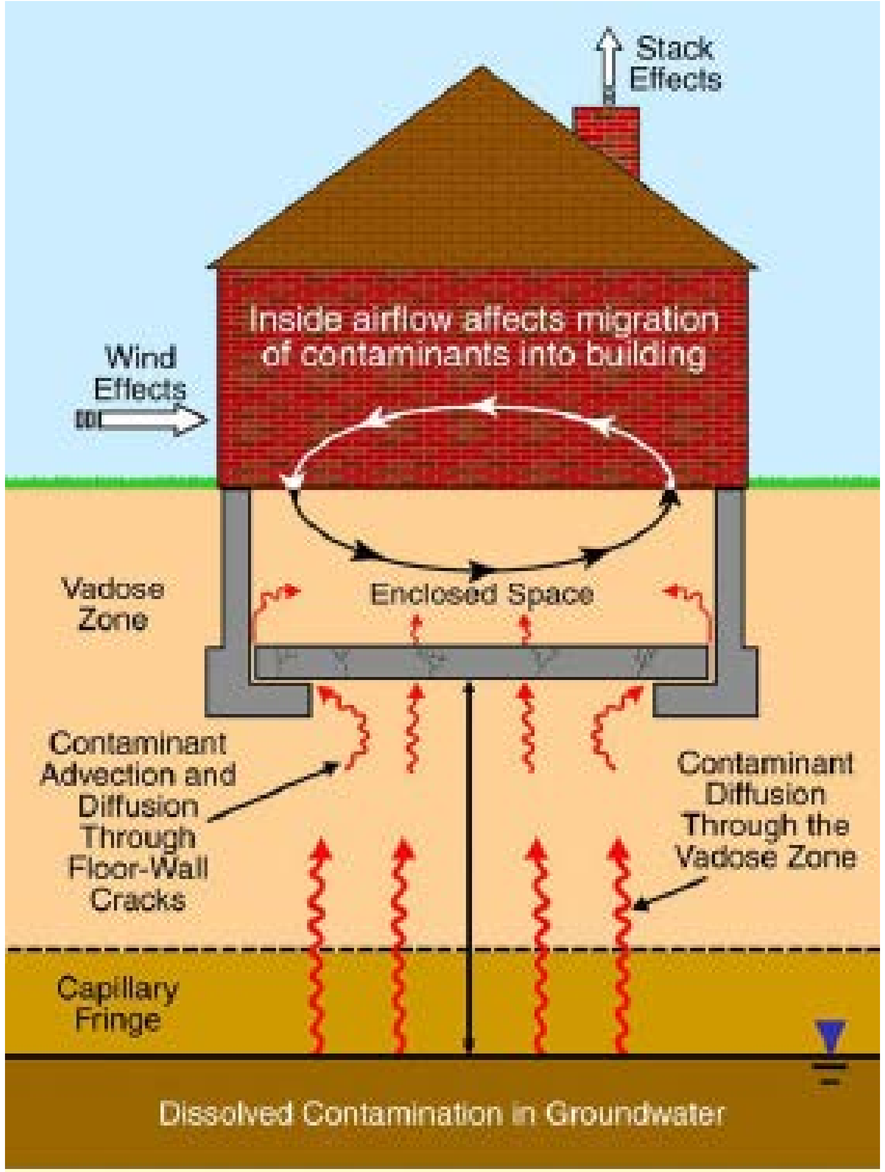
Topics:

- The vapor intrusion (VI) pathway
- VI guidances and screening levels
- VI investigation methods
  - Conventional sampling
  - Technologies/tools to address uncertainties
- VI mitigation for residential buildings
  - Rapid response
  - Long-term mitigation for existing and new buildings
  - Maintenance and monitoring
  - Termination and closure



ITRC (2014)

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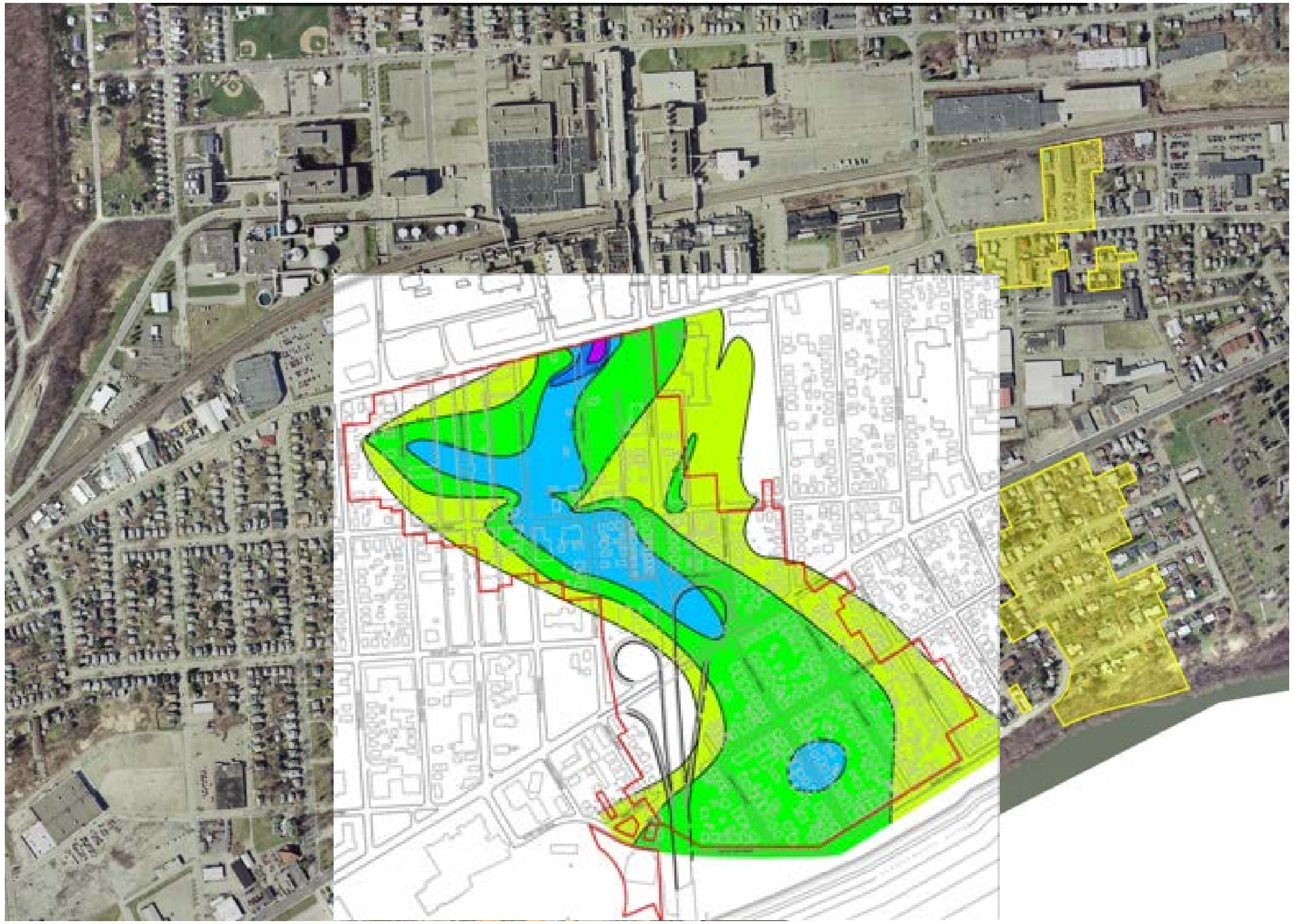
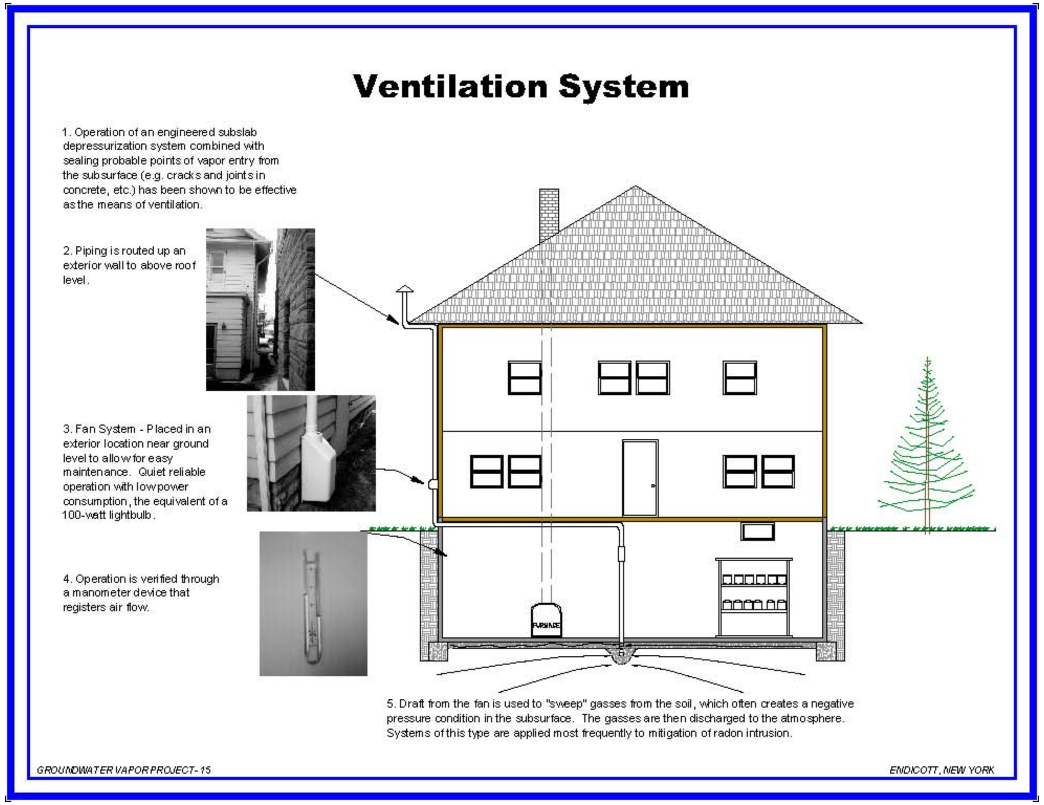
Vapor Intrusion from TCE Plume, Endicott, NY

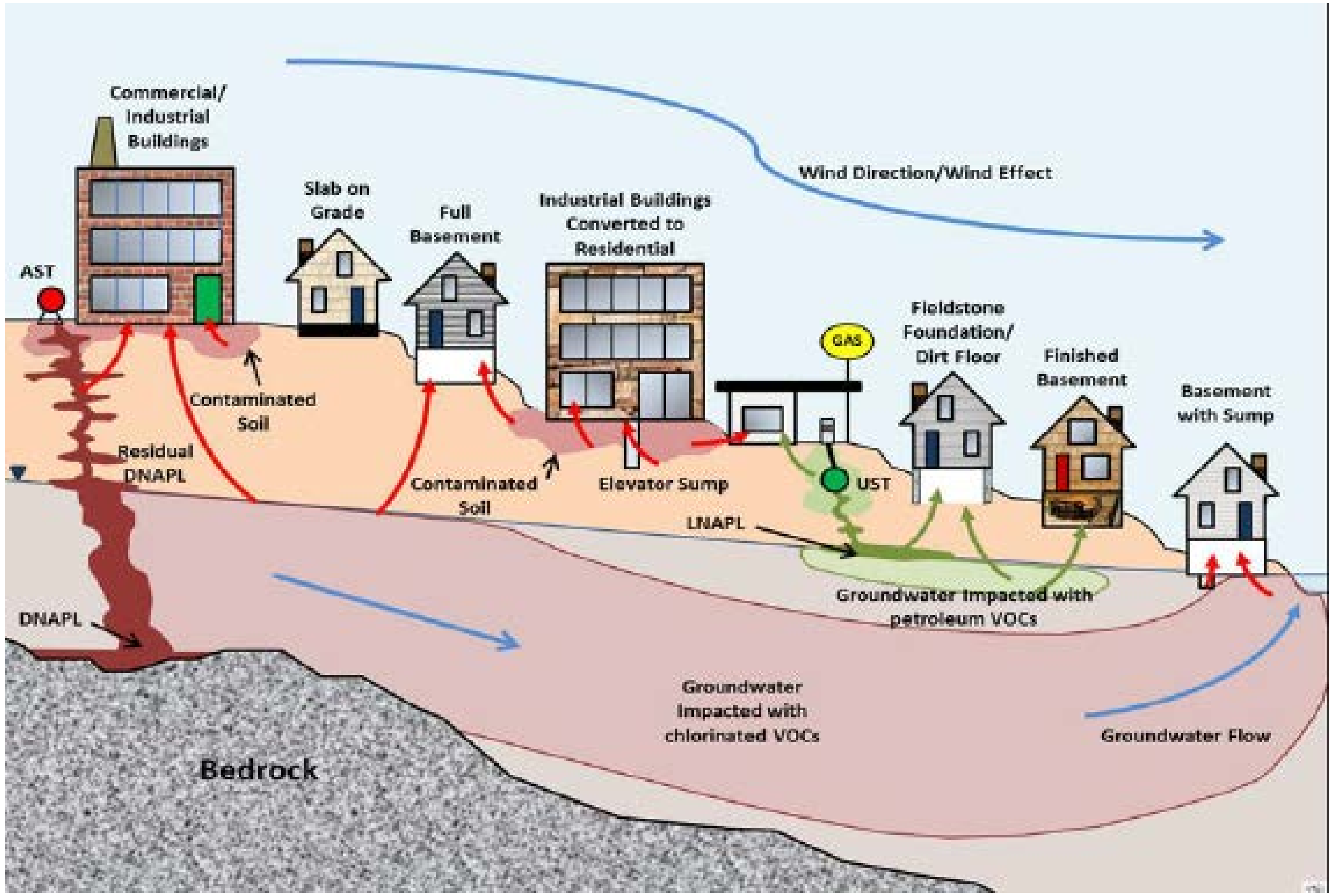


- One of the largest vapor intrusion sites in the US
- Nearly 1000 properties assessed over a 350-acre TCE plume in groundwater
- Successful mitigation of over 450 homes and businesses



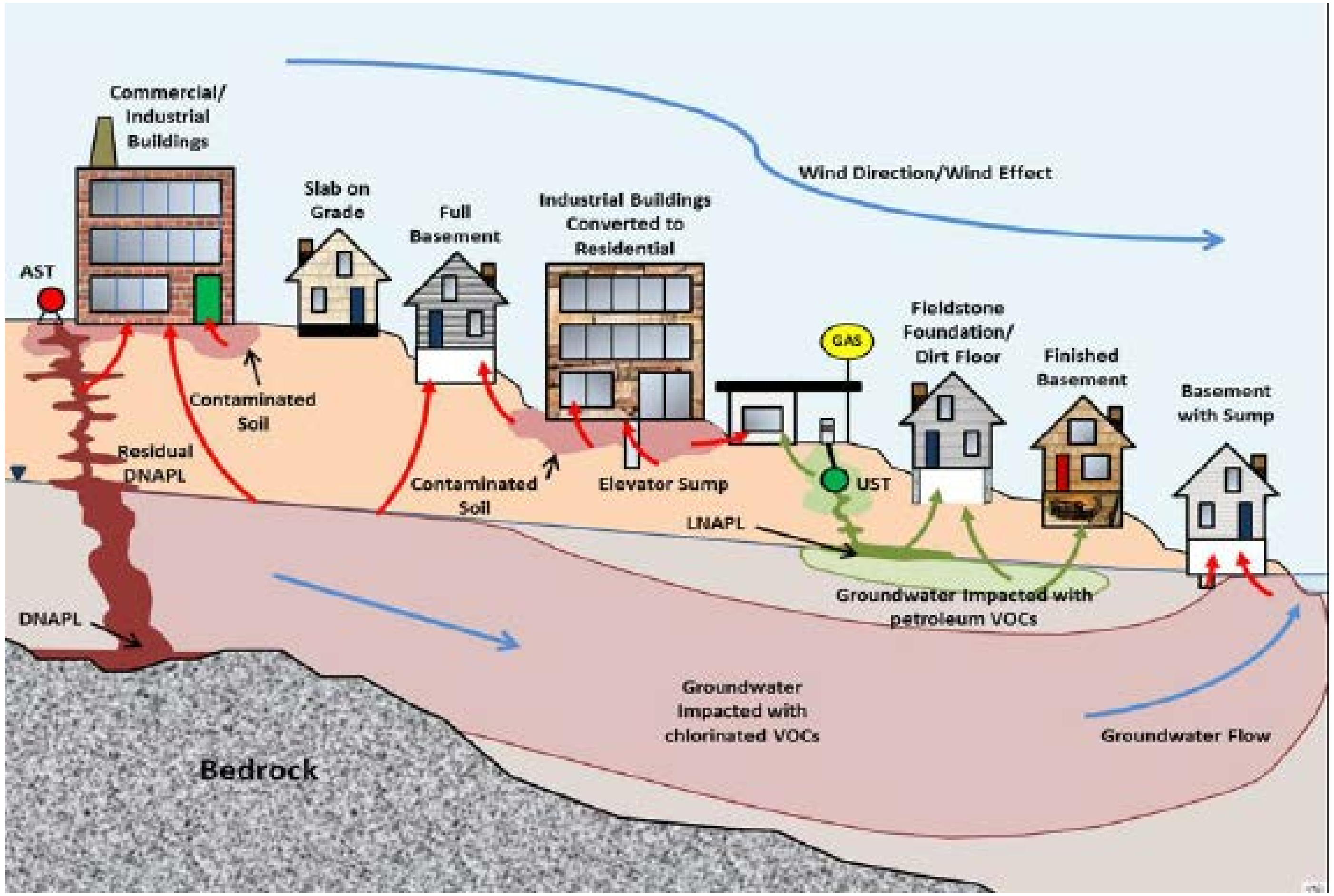
What is Vapor Intrusion?

"Vapor intrusion is the general term given to migration of hazardous vapors from any subsurface contaminant source, such as contaminated soil or groundwater or contaminated conduit(s), into an overlying building or unoccupied structure via any opening or conduit…Vapor intrusion is a potential human exposure pathway". (EPA, 2015 VI Guidance)



Mass DEP VI Guidance, 2016, Fig 2.1

A “complete” VI pathway requires:

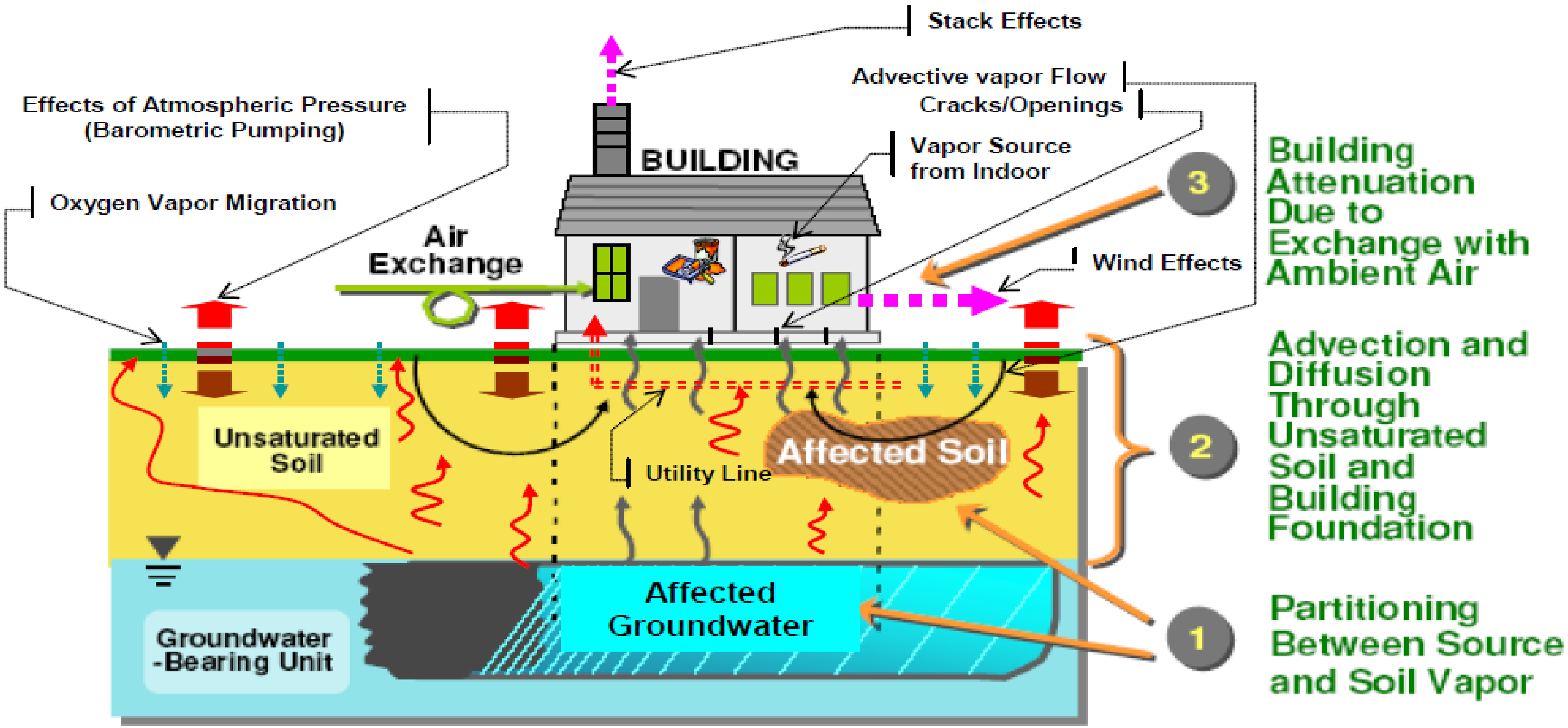


Mass DEP VI Guidance, 2016, Fig 2.1

- A subsurface source of vapor-forming chemicals
- A transport route to a building
- A means of vapor entry into the building (e.g., openings in the foundation)
- One or more receptors (people) in the building when the vapor-forming chemicals are present in indoor air

The VI pathway is incomplete if one or more of the above conditions is absent
(and VI mitigation is not generally warranted)

Key Elements of the Conceptual Site Model for VI



WA Dept of Ecology, VI Guidance, 2022, Fig 1

Chlorinated VOC VI vs. Petroleum VI – USEPA Technical Guides

OSWER Publication 9200.2-154

OSWER TECHNICAL GUIDE FOR ASSESSING AND MITIGATING THE VAPOR INTRUSION PATHWAY FROM SUBSURFACE VAPOR SOURCES TO INDOOR AIR

U.S. Environmental Protection Agency

Office of Solid Waste and Emergency Response

June 2015

EPA United States Environmental Protection Agency

EPA 510-R-15-001

Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites

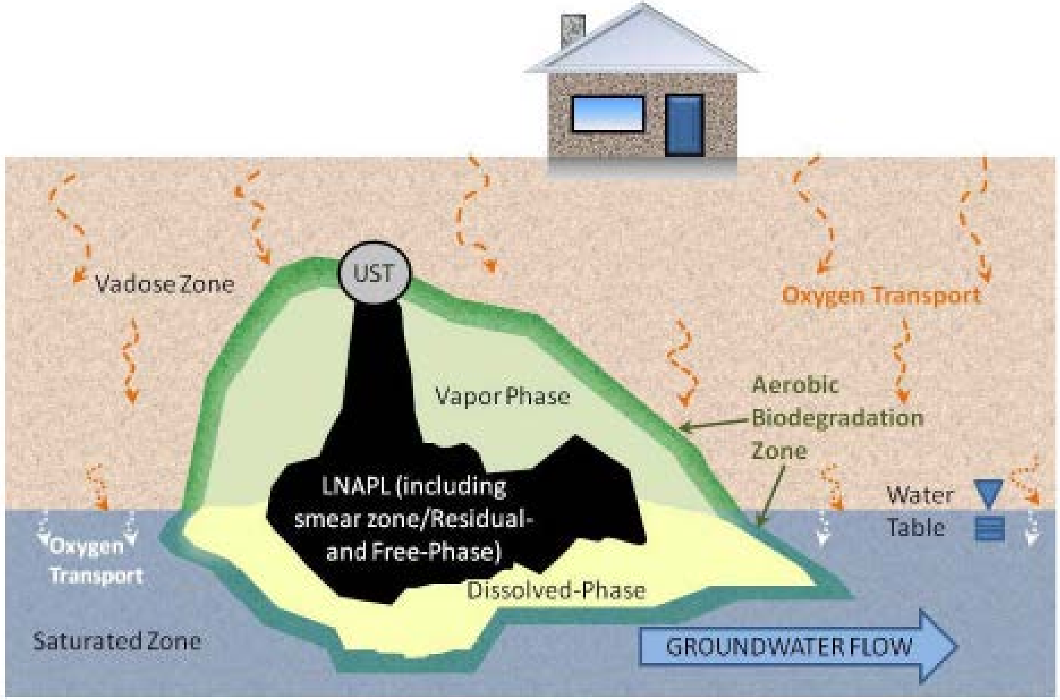
Petroleum Vapor Intrusion (PVI)

U.S. Environmental Protection Agency
Office of Underground Storage Tanks
Washington, D.C.

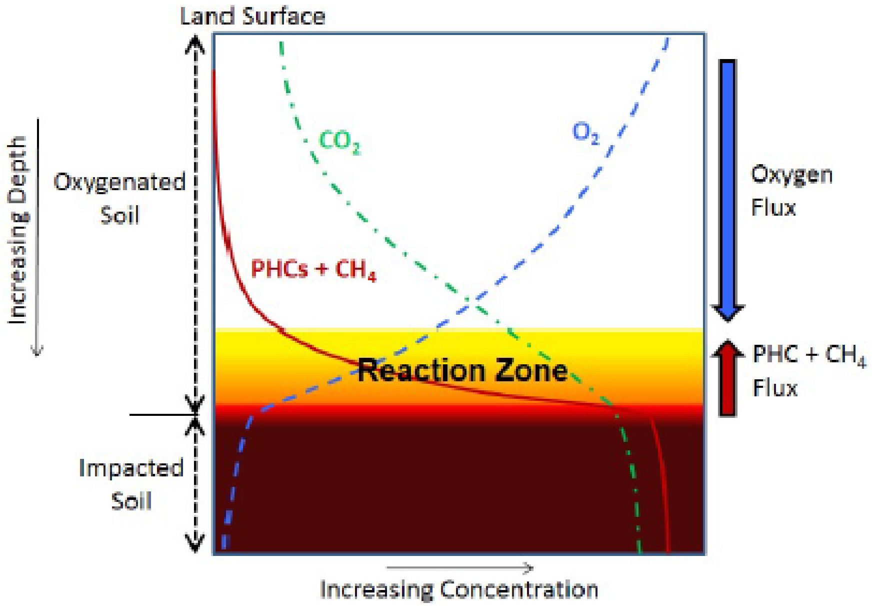
June 2015

Key VOCs associated with PVI from petroleum hydrocarbons (PHCs)

- Benzene, trimethylbenzenes (TMBs), and naphthalene
- Additives such as MTBE, TBA, and EDB
- Methane from biodegradation of PHCs



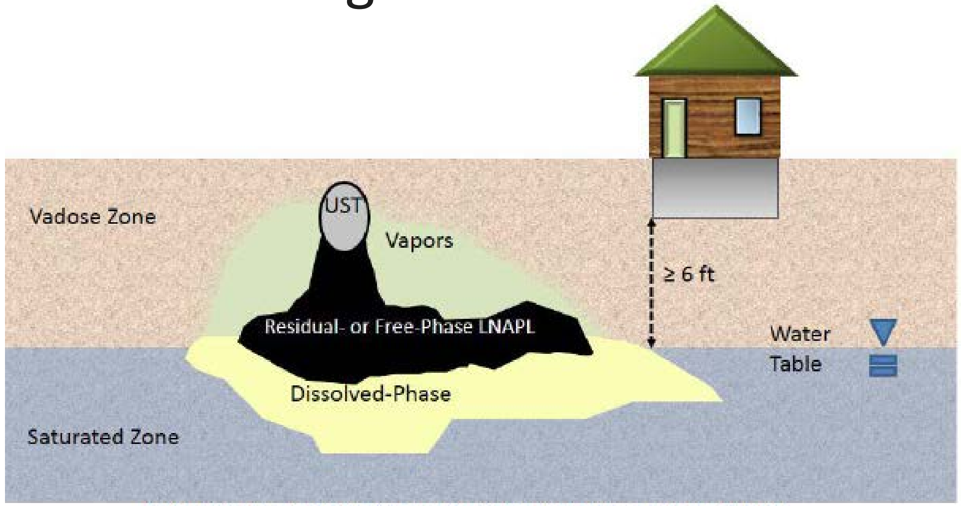
USEPA PVI Guidance, 2015, Fig 2



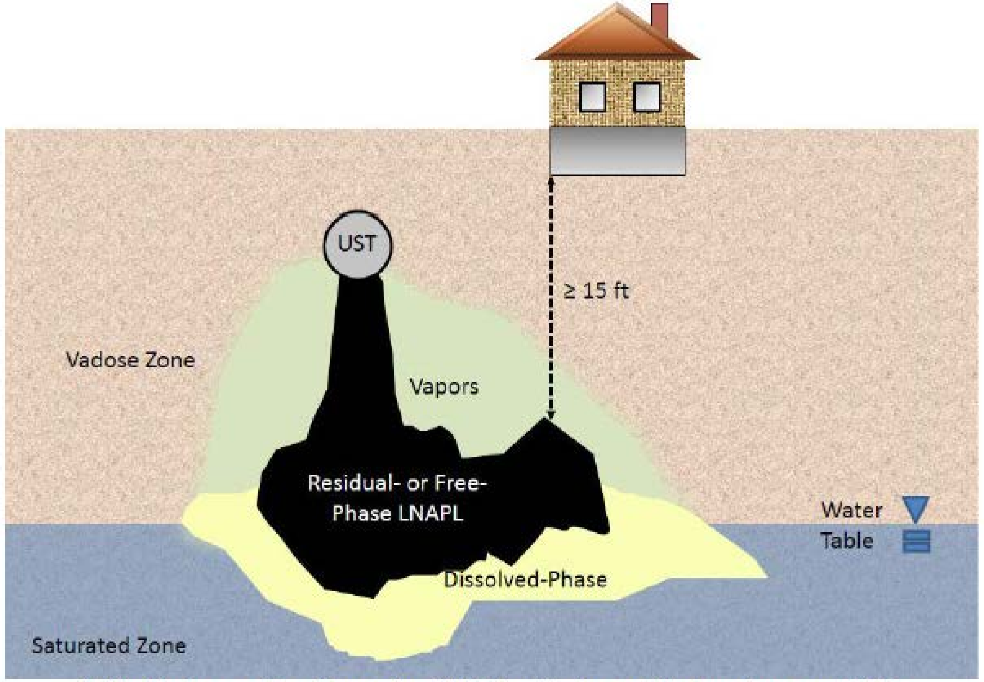
USEPA PVI Guidance, 2015, Fig 8

PHCs generally biodegrade rapidly under aerobic conditions such that the potential for PVI is decreased compared to chlorinated VOCs, which generally persist and degrade anaerobically and slowly

Vertical Screening Distances for Petroleum VI Evaluation



(a) Vertical separation distance for dissolved-phase source of PHCs.



(b) Vertical separation distance for LNAPL (residual or mobile phase) source of PHCs.

USEPA PVI Guidance, 2015, Fig 6

Media	Benzene	TPH	Vertical Separation Distance (feet)*
Soil (mg/Kg)	≤10	≤ 100 (unweathered gasoline), or ≤ 250 (weathered gasoline, diesel)	6
	>10 (LNAPL)	> 100 (unweathered gasoline) >250 (weathered gasoline, diesel)	15
Groundwater (mg/L)	≤5	≤30	6
	>5 (LNAPL)	>30 (LNAPL)	15

Threshold for LNAPL (Soil: >10 (LNAPL))

Threshold for LNAPL (Groundwater: >5 (LNAPL))

USEPA PVI Guidance, 2015, Table 3

*The vertical separation distance represents the thickness of clean, biologically active soil between the source of PHC vapors (LNAPL, residual LNAPL, or dissolved PHCs) and the lowest (deepest) point of a receptor (building basement floor, foundation, or crawlspace surface).

Screening distances for VI assessment – Massachusetts example

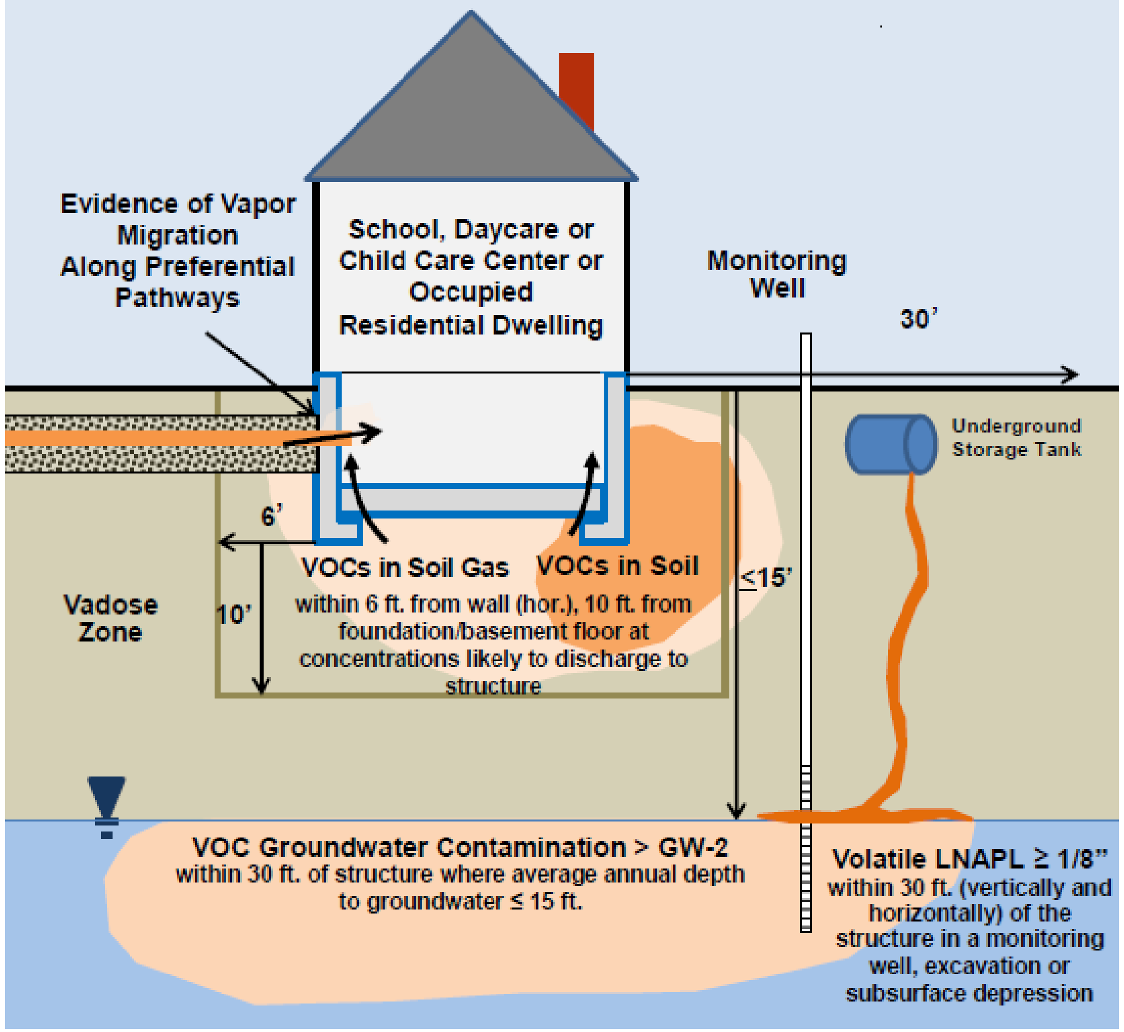


Fig 4-1 of MassDEP VI Guidance, 2016, 72-Hour Notification Requirement

VOC Proximity to Building	Horizontal	Vertical
VOCs in soil or soil gas	6 ft	10 ft
VOCs in dissolved phase plume > GW-2 standard	30 ft	15 ft
VOCs in dissolved phase plume > 10X GW-2 standard	100 ft	15 ft
Volatile LNAPL	30 ft	30 ft

NEWMOA-member States' VI Guidance

State	Department	Status of VI Guidance
Connecticut	Dept of Energy and Environmental Protection	Concurrence (Oct 2017) with ITRC VI Guidance (2007); Remediation Standard Regulations – Volatilization Criteria
Maine	Dept of Environmental Protection	Supplemental VI guidance (Feb 2016) to USEPA VI guidance (2015)
Massachusetts*	Dept of Environmental Protection	Oct 2016 VI guidance
New Hampshire	Dept of Environmental Services	July 2006 VI guidance w/Feb 2013 revision
New Jersey*	Dept of Environmental Protection	May 2021 VI guidance (ver 5.0)
New York	Dept of Environmental Conservation	2006 VI Guidance
Rhode Island	Dept of Environmental Management	No stand-alone VI guidance (VI addressed in remediation regs);
Vermont*	Dept of Environmental Conservation	March 2020 VI Guidance

*MA, NJ, and VT most recent and detailed on VI data collection methods

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VOC screening thresholds typically used to determine if additional investigation of the vapor intrusion pathway is required

Example – VI residential screening values for TCE

Media	Units	CT	MA	ME	NJ	NH	NY	RI	VT	USEPA
Indoor Air	ug/m^3	1	0.4	2.1	3	0.4	2	None	0.5	0.48
Soil Gas*	ug/m^3	760	28	63	27	20	Varies	None	5 (< 5 ft) 50 (>5 ft)	16
Groundwater	ug/l	27	5	None	2	20	None	None	1.19	1.2

*Preference for subslab soil gas over exterior soil gas

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Attenuation Factor and Screening Levels

$$\text{Attenuation factor} = \alpha = C_{\text{indoor air}} / C_{\text{subsurface}}$$

$$C_{\text{screening level, soil gas}} = C_{\text{target indoor air}} / \alpha$$

$$C_{\text{screening level, groundwater}} = C_{\text{target indoor air}} / (\alpha \times H \times 1000\ L/m^3)\ ,\ \ H = \text{Henry's law constant}$$

TABLE 6-1
RECOMMENDED VAPOR ATTENUATION FACTORS FOR RISK-BASED SCREENING OF THE VAPOR INTRUSION PATHWAY[184]

Sampling Medium	Medium-specific Attenuation Factor for Residential Buildings
Groundwater, generic value, except for shallow water tables (less than five feet below foundation) or presence of preferential vapor migration routes in vadose zone soils	1E-03 (0.001)
Groundwater, specific value for fine-grained vadose zone soils, when laterally extensive layers are present[185]	5E-04 (0.0005)
Sub-slab soil gas, generic value	3E-02 (0.03)
"Near-source" exterior soil gas, generic value except for sources in the vadose zone (less than five feet below foundation) or presence of routes for preferential vapor migration in vadose zone soils	3E-02 (0.03)
Crawl space air, generic value	1E-00 (1.0)

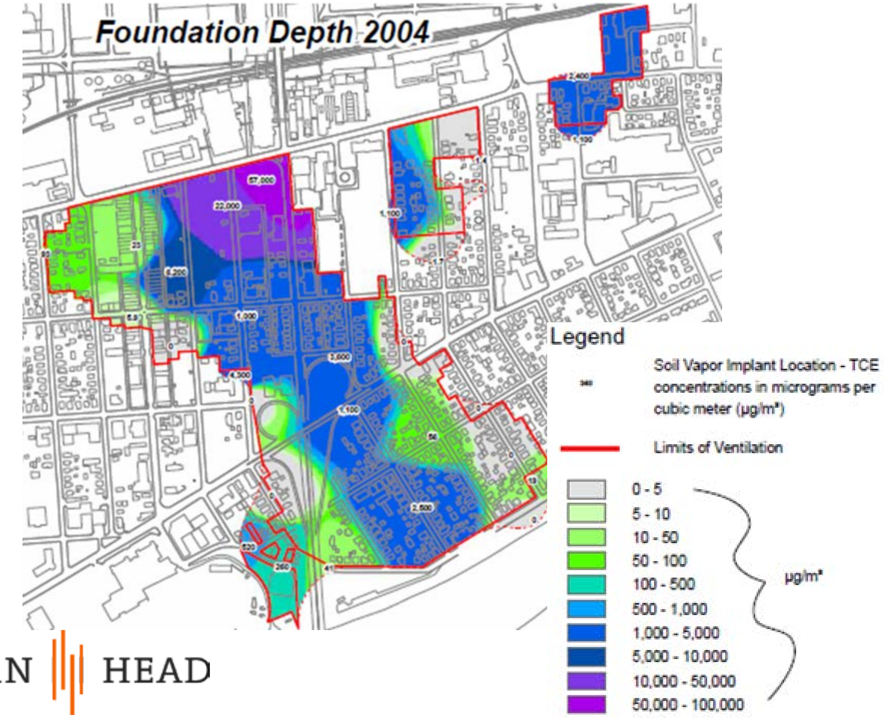
Many states have adopted the USEPA attenuation factors in establishing VI screening levels for soil gas and groundwater

USEPA VISLs https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator

Investigation Sampling Methods

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

Exterior soil gas sampling



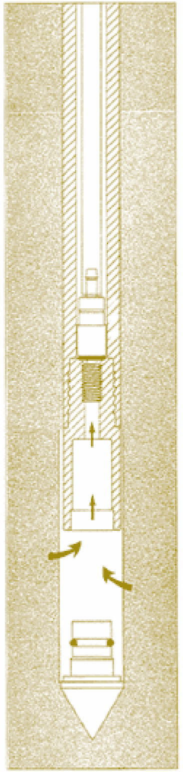
Pros

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

Cons

- Sub-slab 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.

Exterior soil gas sampling probe – single event equipment

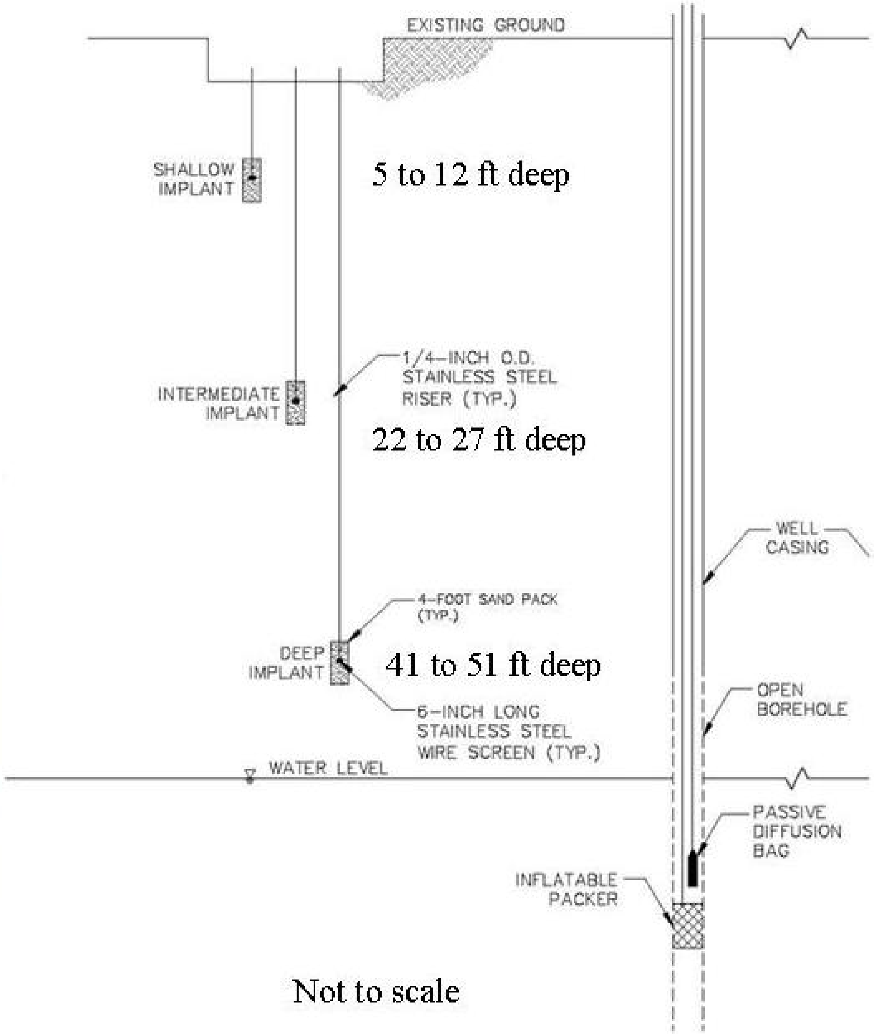


Retractable drive point connect to flexible tubing through hollow rod

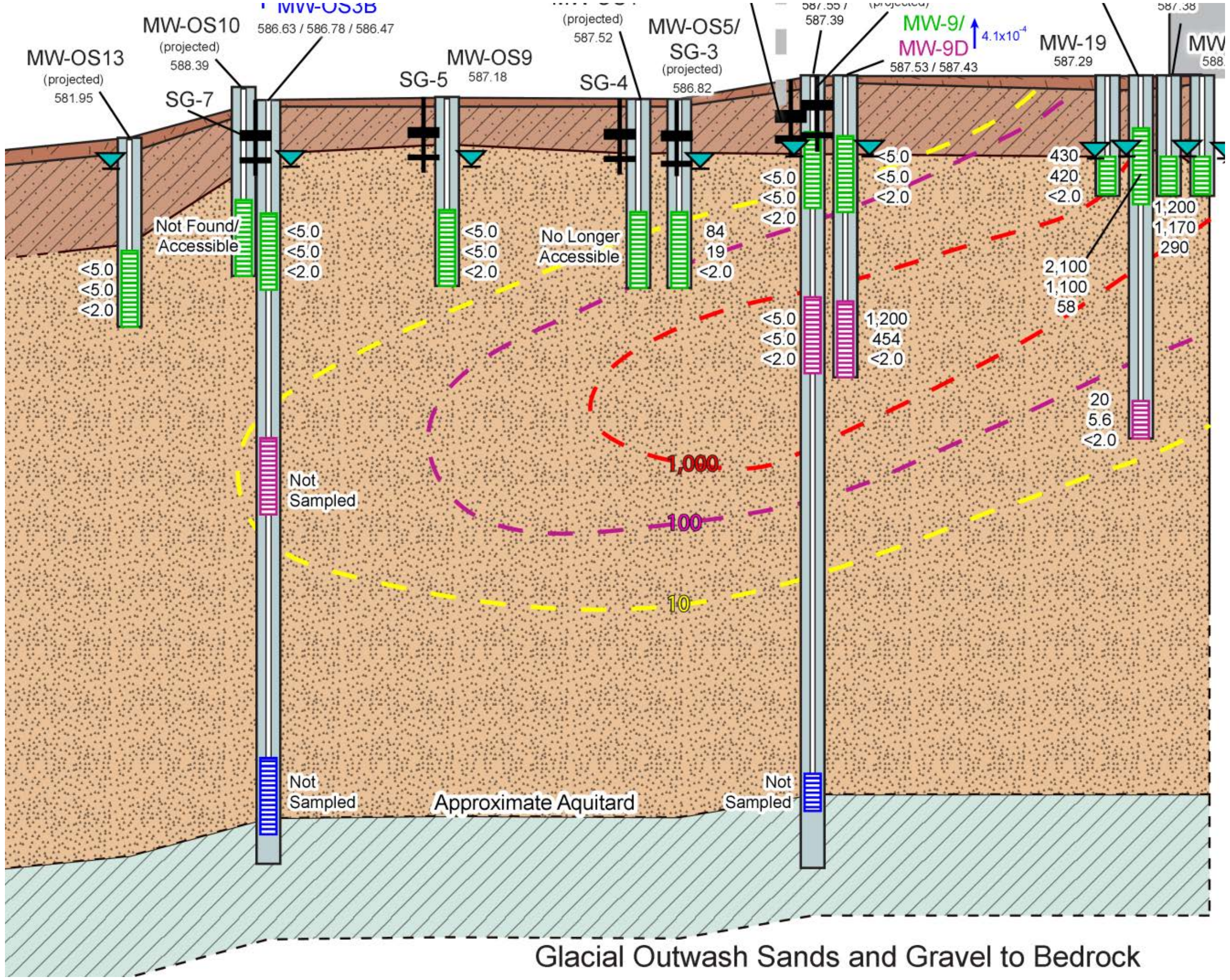
Hand-driven tools

Hydraulic push tools

Exterior soil gas sampling probe – permanent monitoring



Example of exterior investigation to rule out off-site VI – Pathway not complete



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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Sub-slab soil gas sampling – single event

Temporary hole drilled through slab and sealed with hot beeswax

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Subslab port installation – permanent installation used for:

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

or

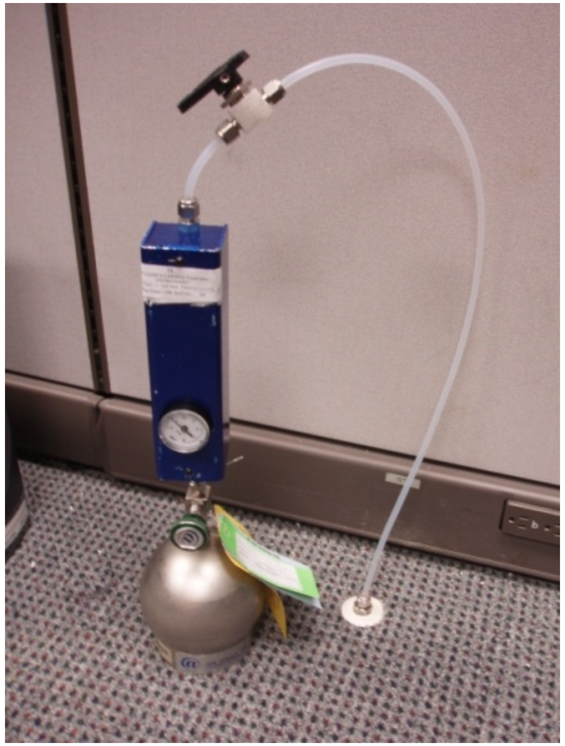
Commercial product

VaporPin®

https://www.vaporpin.com/

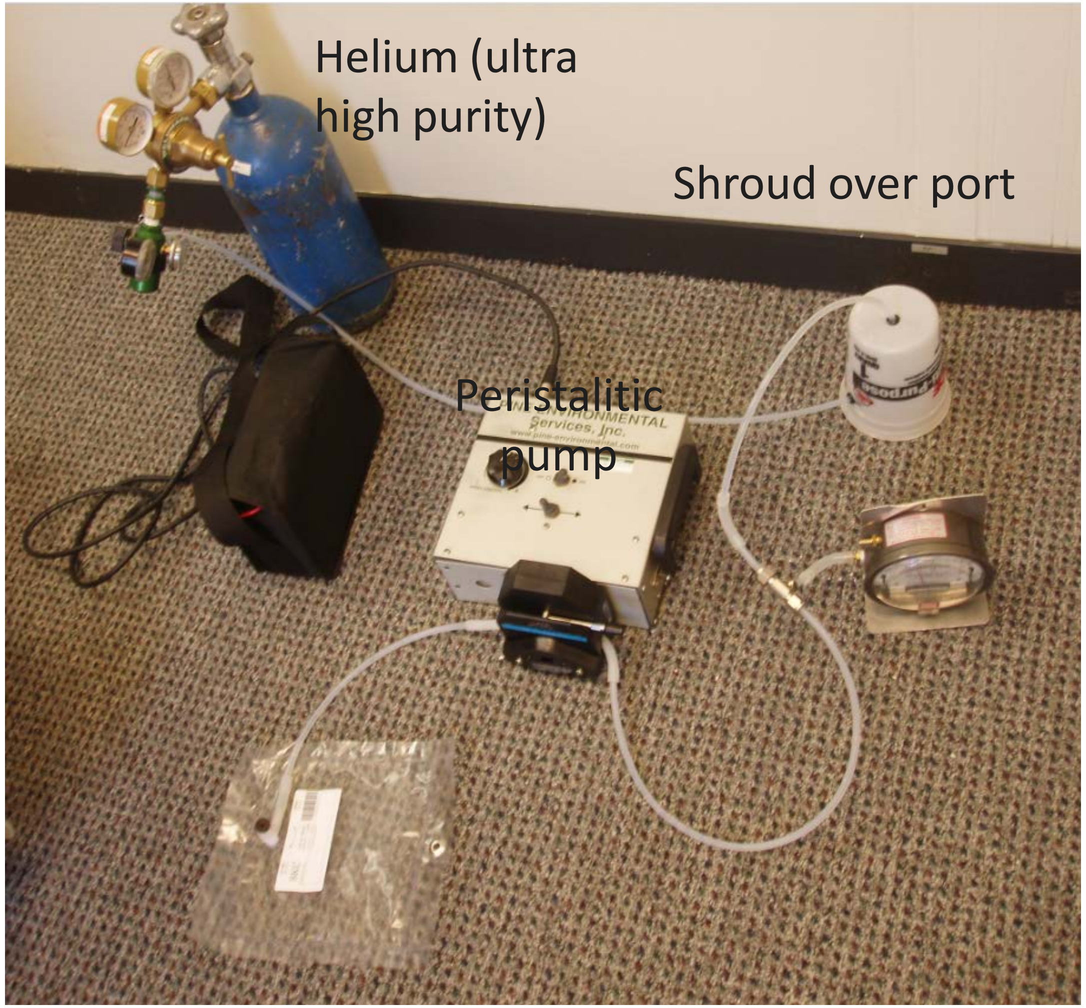
Subslab vapor sampling

Integrity/leak testing of port construction



Sampling into Summa® canister

Collection of primary and field duplicate samples



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, 2021

"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	

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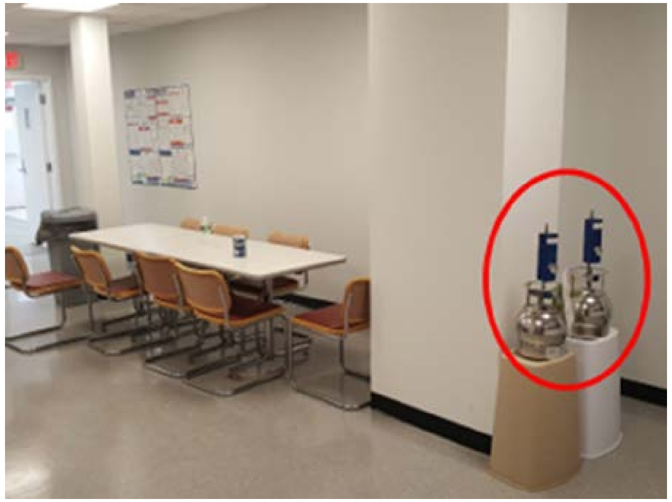
Indoor Air Sampling



Typical State guidelines:

- Conduct pre-sampling building inventory/assessment
- Use stainless steel canisters (Summa®) for lab analysis of VOCs 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

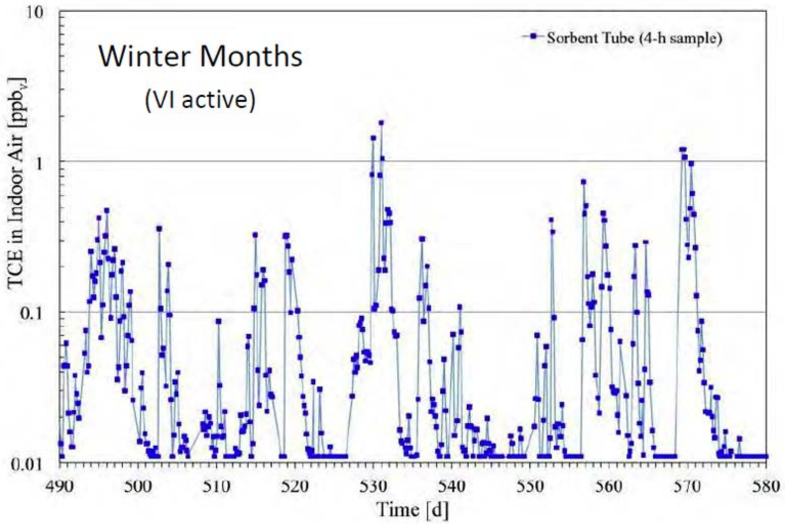
Sampling with Summa® canisters

Sources of Error or Bias	QA/QC Measures	Lessons Learned
Contaminated canisters or flow 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:

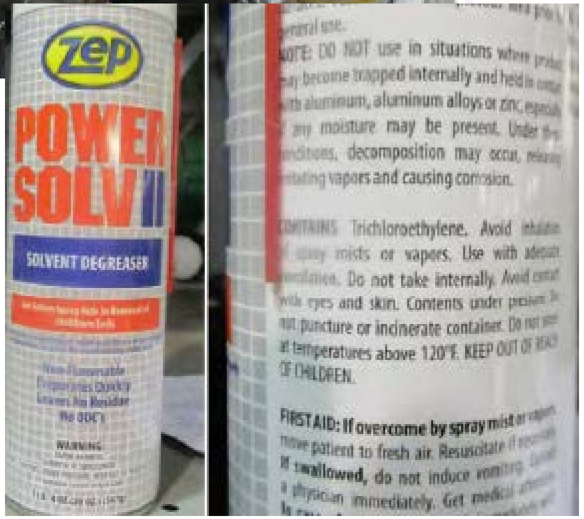
1. Background/indoor sources of VOCs

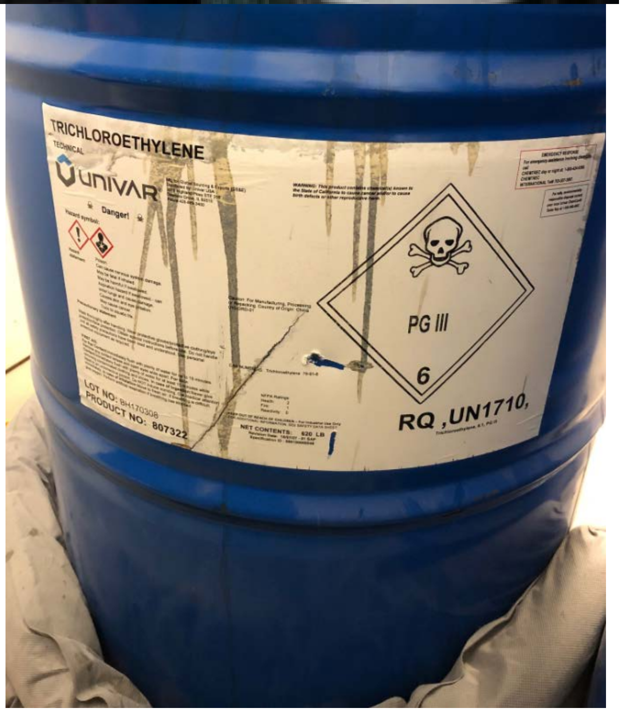
2. Time variability of VI



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

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





Indoor Air Sampling – Beware of indoor sources

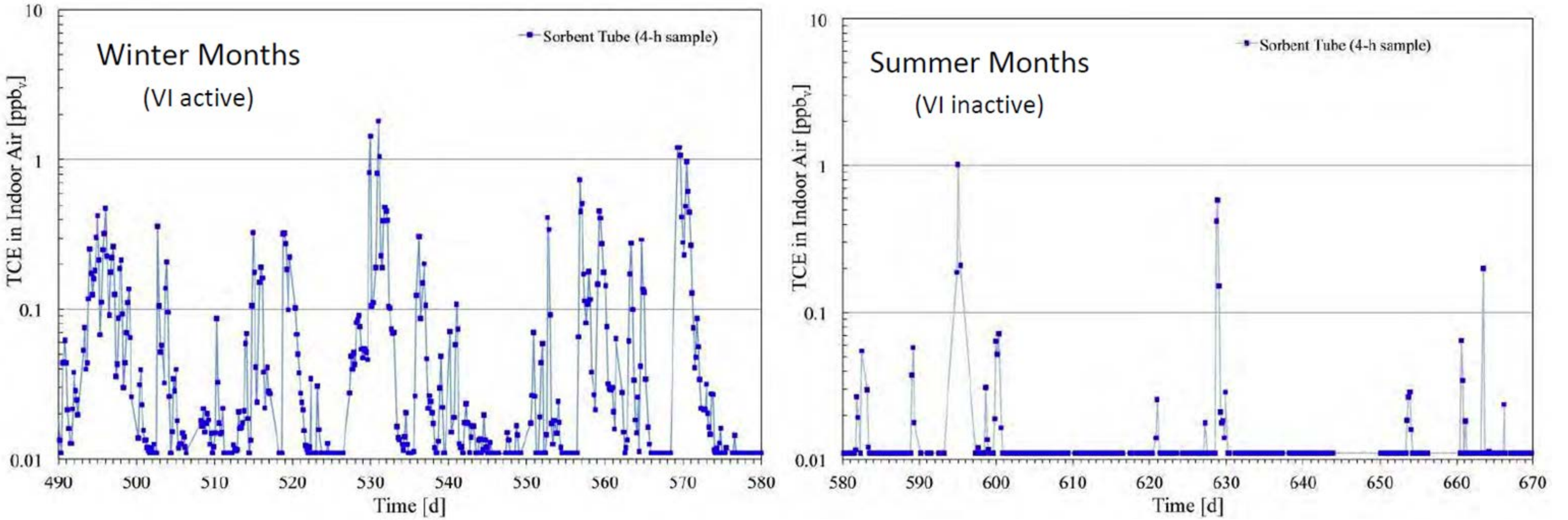
Indoor sources of VOCs

- Household and commercial products
- Dry-cleaned clothes
- Building materials (paints, finishes, carpets, adhesives, etc.)
- Gasoline, attached garages
- 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



Arizona State U. Research House, Layton, UT

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

Variability in VOC concentrations spans 1 to 2 orders of magnitude

Assuming one or two 24-hour samples:

- High potential to miss VI episodes (false negative)
- High potential to overestimate long-term exposure if sampling occurs during episodic VI (false positive)
- High potential to miss max short-term exposure (false negative)

KEY POINT: A random 24-hr sample represents neither the worst-case short-term nor the long-term average

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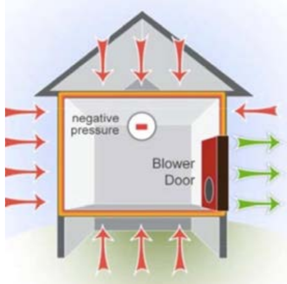
How many indoor air sampling events?

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

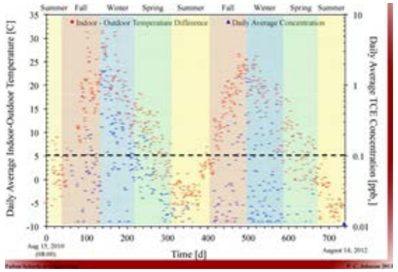
Technologies/tools to evaluate VI variability and exposure risk

1. Real-time monitoring and screening



2. Building pressure tests

3. Longer-term samples



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

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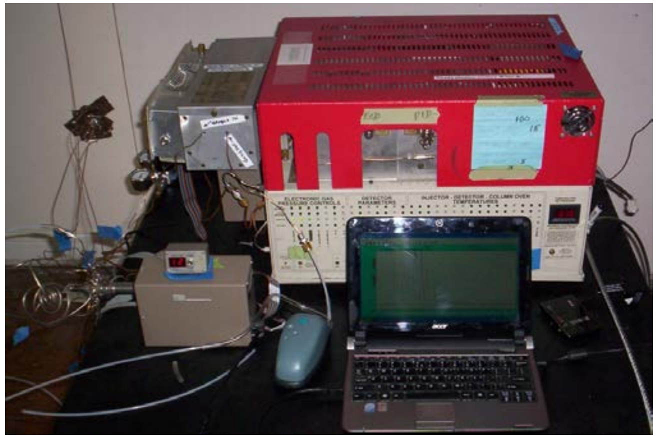
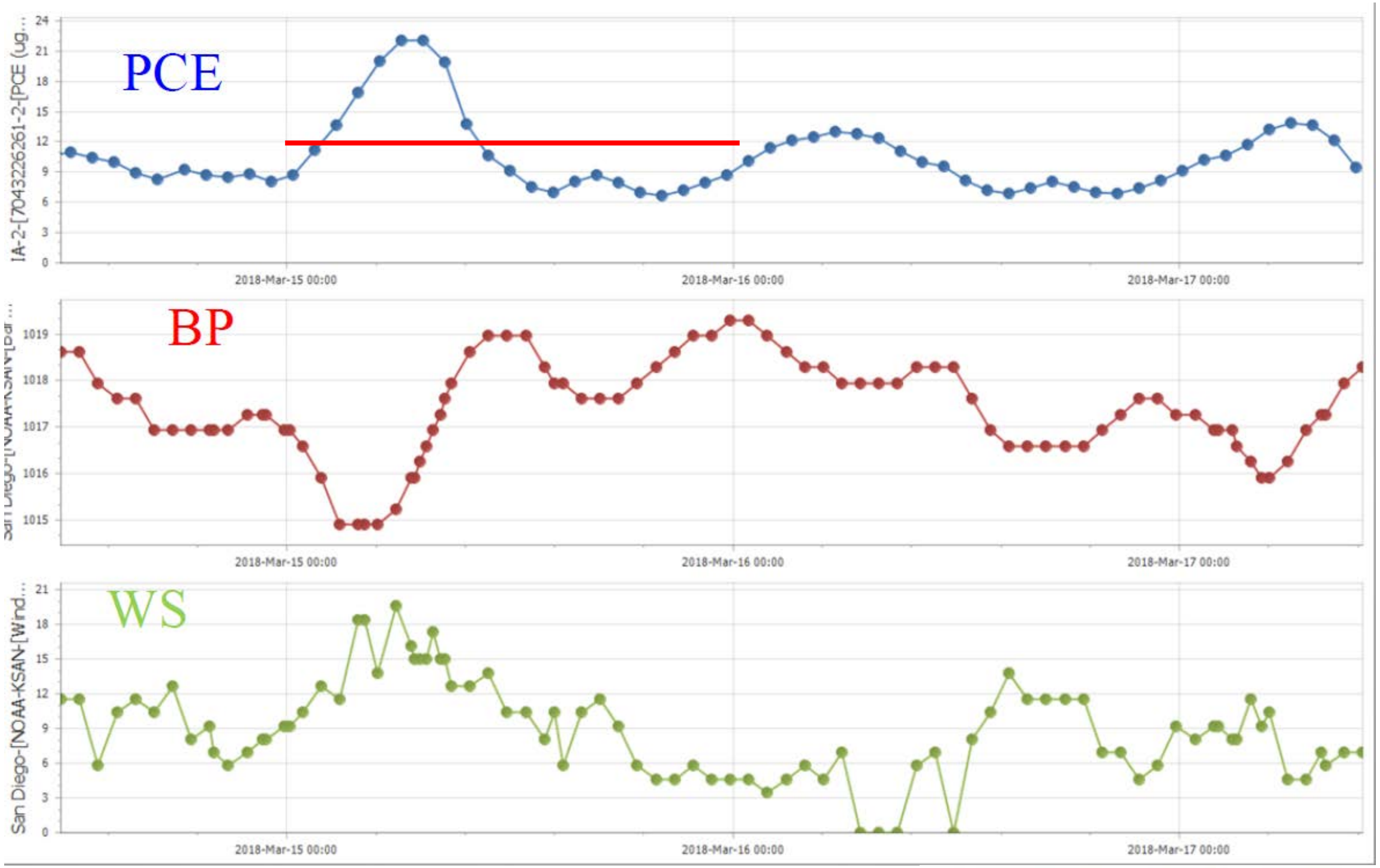
Continuous monitoring reveals variability





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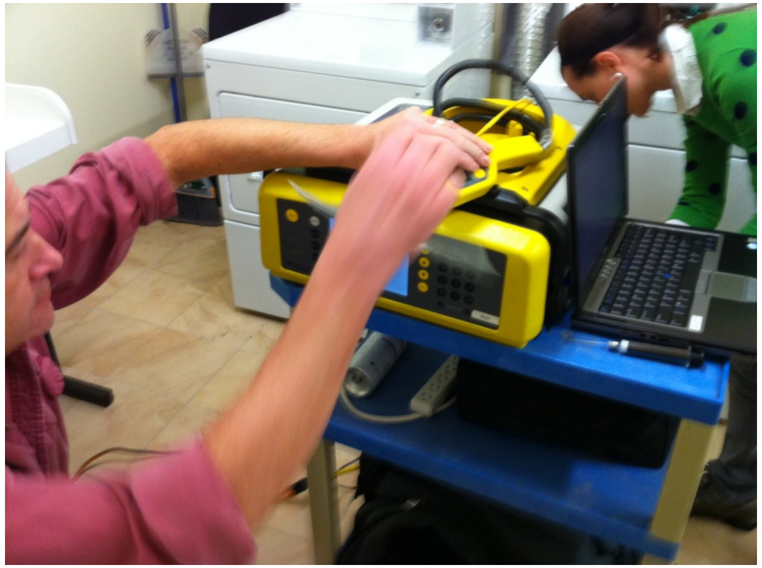
EARTH MONITORING SOFTWARE

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)

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

Sniffing for VI from cracks under rugs

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

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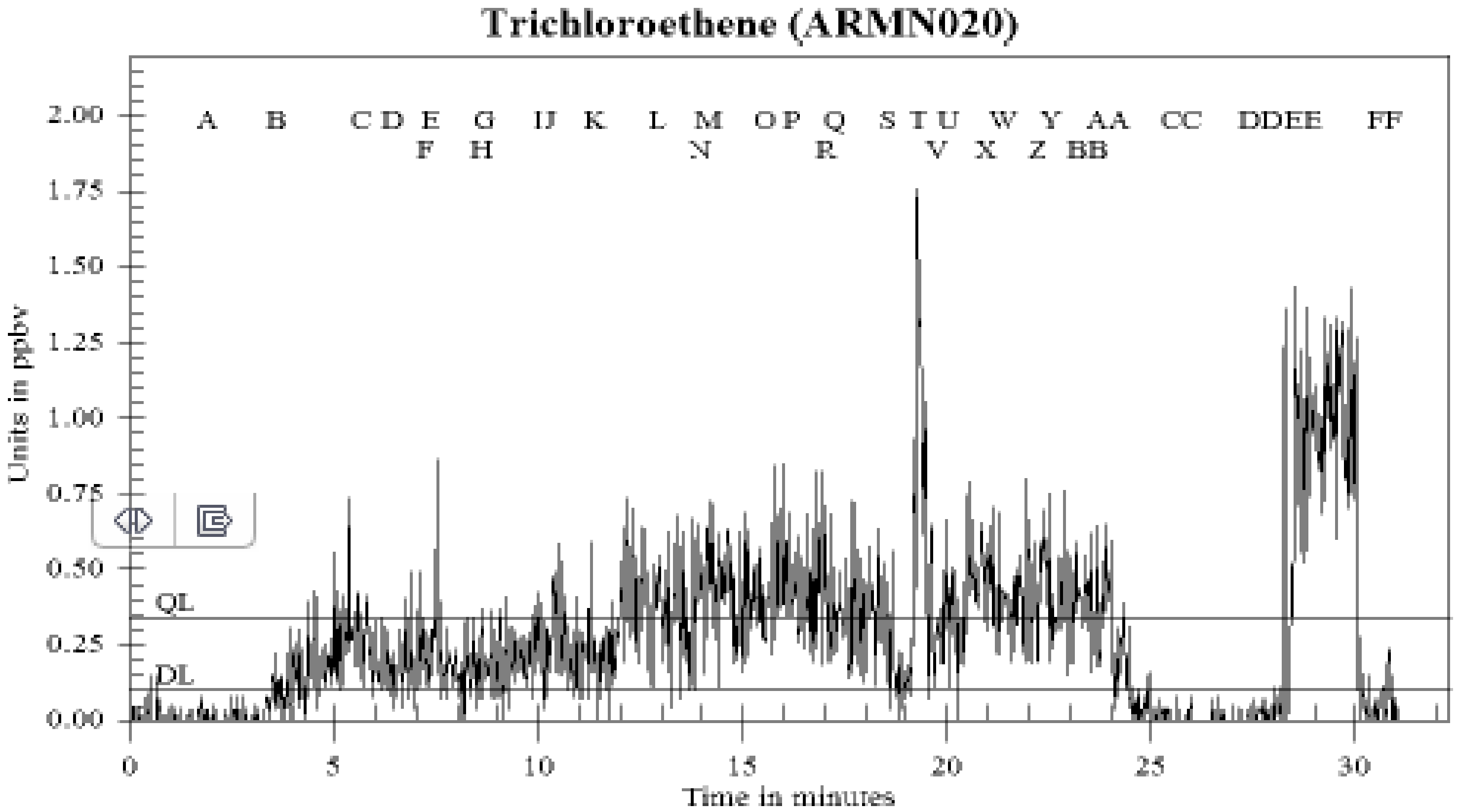
Courtesy of StoneHill Environmental

Real-time continuous VI sampling using EPA's Trace Atmospheric Gas Analyzer (TAGA) Mobile Laboratories https://www.epa.gov/ert/trace-atmospheric-gas-analyzer-taga



For more information:

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

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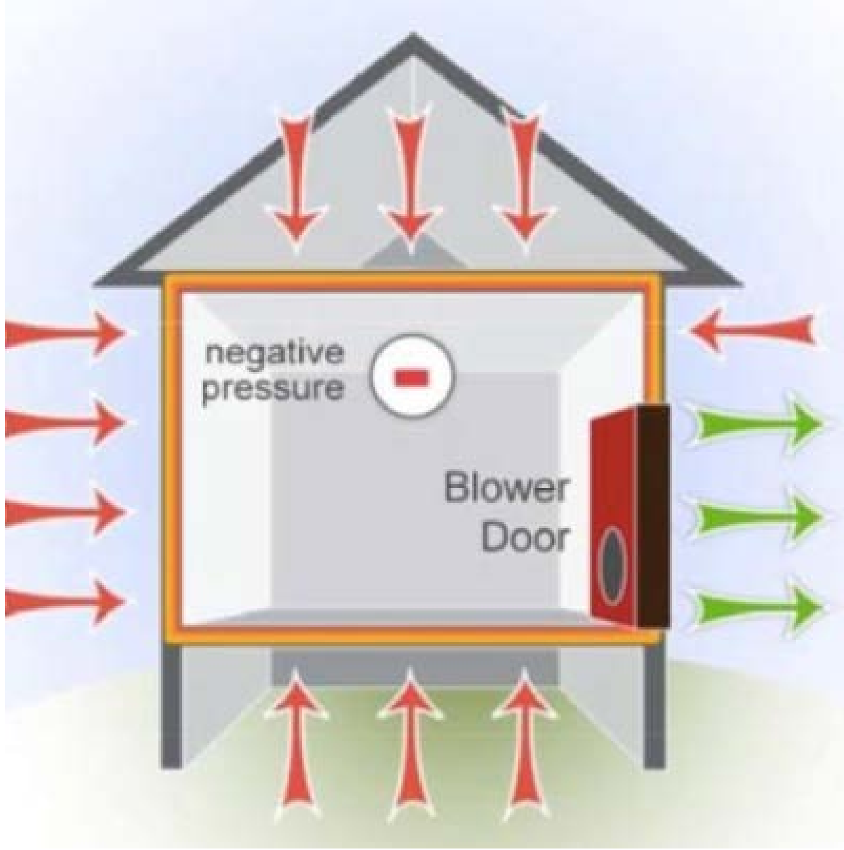
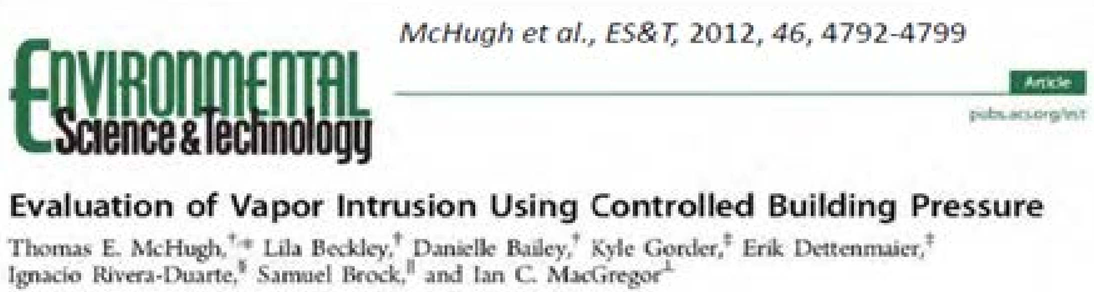
VI Diagnostic Tool: Building Pressure Tests




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

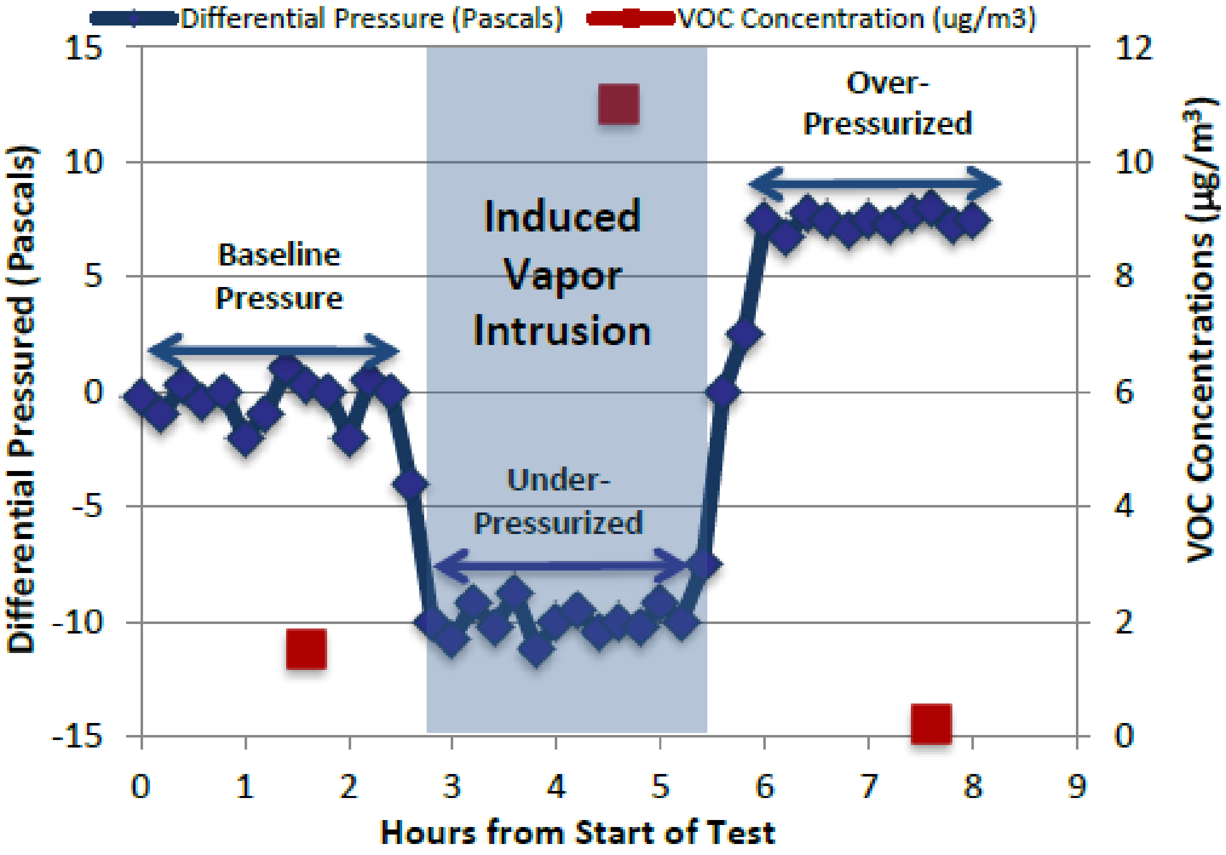
Environmental Science & Technology

Article

pubs.acs.org/est

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[⊥]



Negative pressure: favors VI

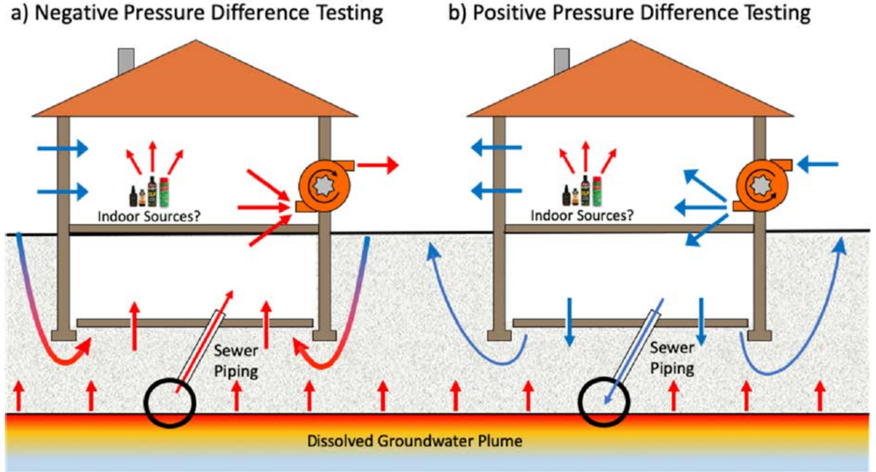
Positive pressure: suppresses VI

Environmental Science & Technology

pubs.acs.org/est Article

Development and Validation of a Controlled Pressure Method Test Protocol for Vapor Intrusion Pathway Assessment

Yuanming Guo,* Paul Dahlen, and Paul C. Johnson

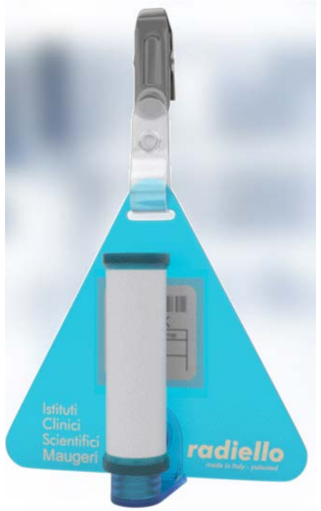


Guideline	Neg. Pressure Test	Pos. Pressure Test
Fan Location	Door or window	Door or window
Fan operating condition	Adjust flow to achieve -10 to -15 Pa (-0.04 to -0.06 wc) indoor/outdoor pressure difference	Adjust flow to achieve +10 to +15 Pa indoor/outdoor pressure difference
Duration	At least 9 air exchanges = 9 x bldg. vol/fan flow rate	4 air exchanges = 4 x bldg. vol/ fan flow rate
Air sample collection	Sample at fan intake, in each room of interest, outdoor air	Sample outdoor air and in each room of interest
Data Evaluation	Indoor VOC levels greater than initial conditions indicate VI	Indoor VOC levels greater than outdoor indicate indoor source(s)

Long-term Sampling Devices (passive samplers)

BEACON ENVIRONMENTAL

SiREM



radiello®

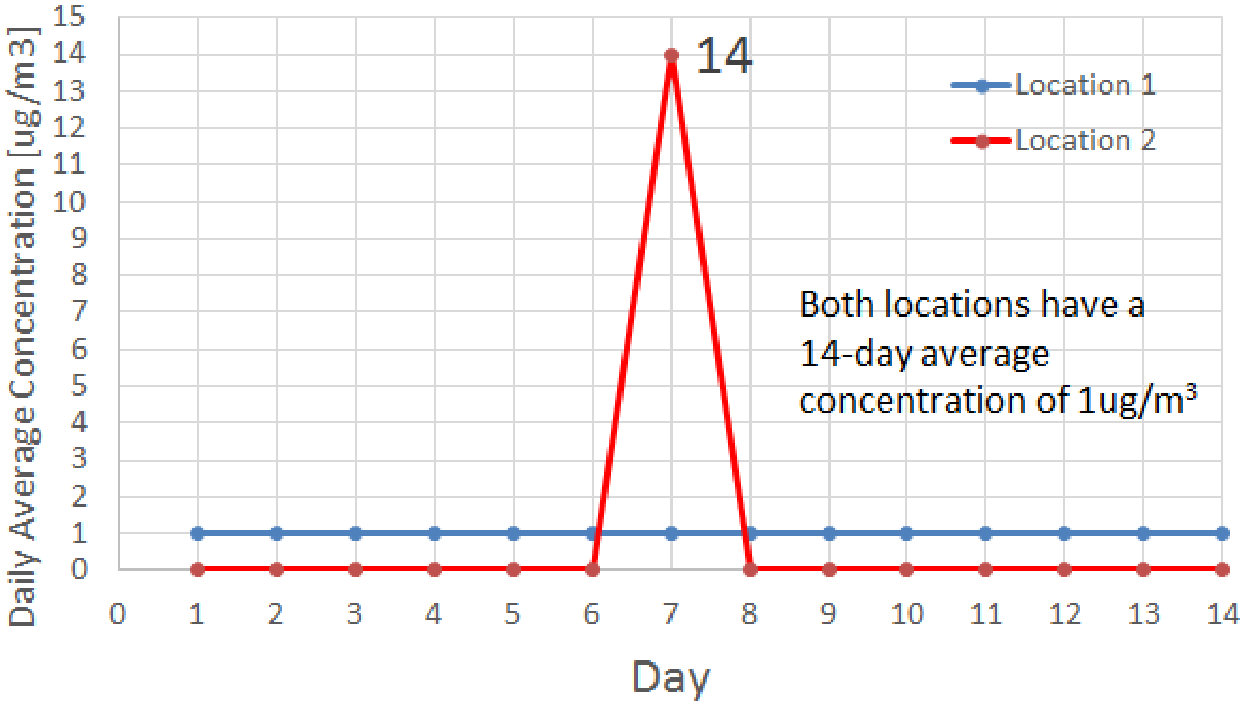
Pros

- 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

Caveats

- 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 TO-15 samples for final risk exposure decisions

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 (0.43 x 14 = 6)

SANBORN HEAD

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

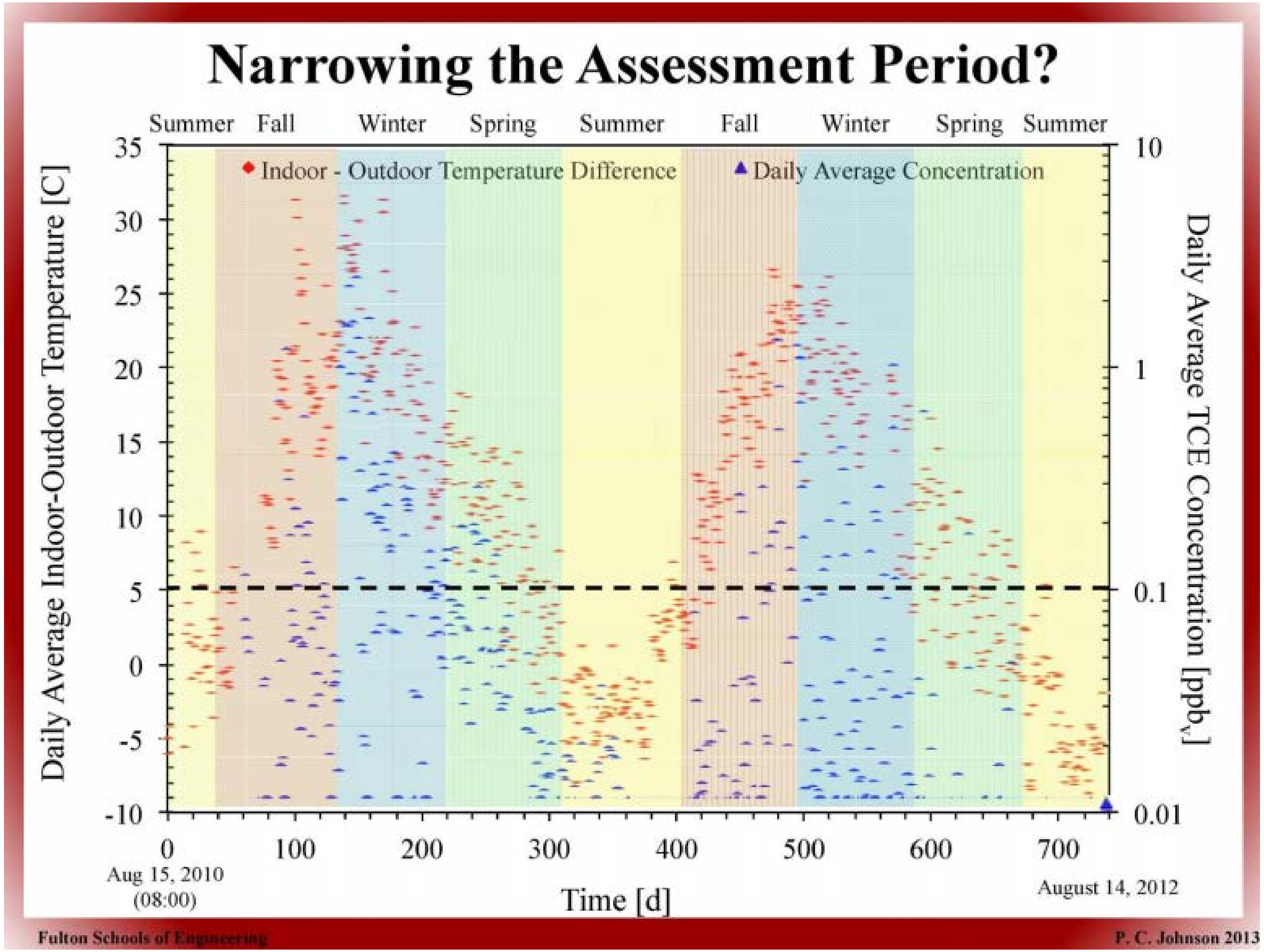
May 2015

ESTCP

ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM

U.S. Department of Defense

Guided Sampling: Current research topic on the use of indicator parameters such as temperature, pressure, and radon to sample indoor air when VI is most likely



Sun Devil Manor, UT

Resource for "State of VI Science"

https://iavi.rti.org/workshops.html

Workshops and Conferences

Recent Events:

EPA's 2023 "State of VI Science" Workshop Session #4 at AEHS West: Selecting Sampling Strategies for Efficient & Economical Vapor Intrusion Site Assessment & Long-Term Management forming Soil Gas Safe Communities

Agenda Download Agenda

Introduction: Verifying Cleanups Near Receptors
Henry Schuver Download Presentation Watch Video

Agenda and Workshop Themes/Goals
Brian Schumacher Download Presentation Watch Video

State and Regional Vapor Intrusion Site Assessment Guidance [As of Fall 2022]
Chris Lutes and Laurent Levy Download Presentation Watch Video

Why go "above and beyond" to collect defensible VI data?
Theresa Gabris Download Presentation Watch Video

Sampling Strategy Performance: Daily and Weekly Durations: Comparing Random, Seasonal and Indicator- & Tracer-Guided
Chris Lutes, AJ Kondash, and Chase Holton Download Presentation Watch Video

Panel Discussion: Nature and severity of the problem
Moderated by Alana Lee Watch Video

Vapor Intrusion Assessment with Different Foundation Types
Hong (Emma) Luo Download Presentation Watch Video

Automated Continuous High-Frequency Vapor and Controlling Factor Monitoring for Reasonable Maximum Exposure, Cost Effective Decision Making, and Risk Reduction
Mark Kram, Blayne Hartman, and Cliff Frescura Download Presentation Watch Video

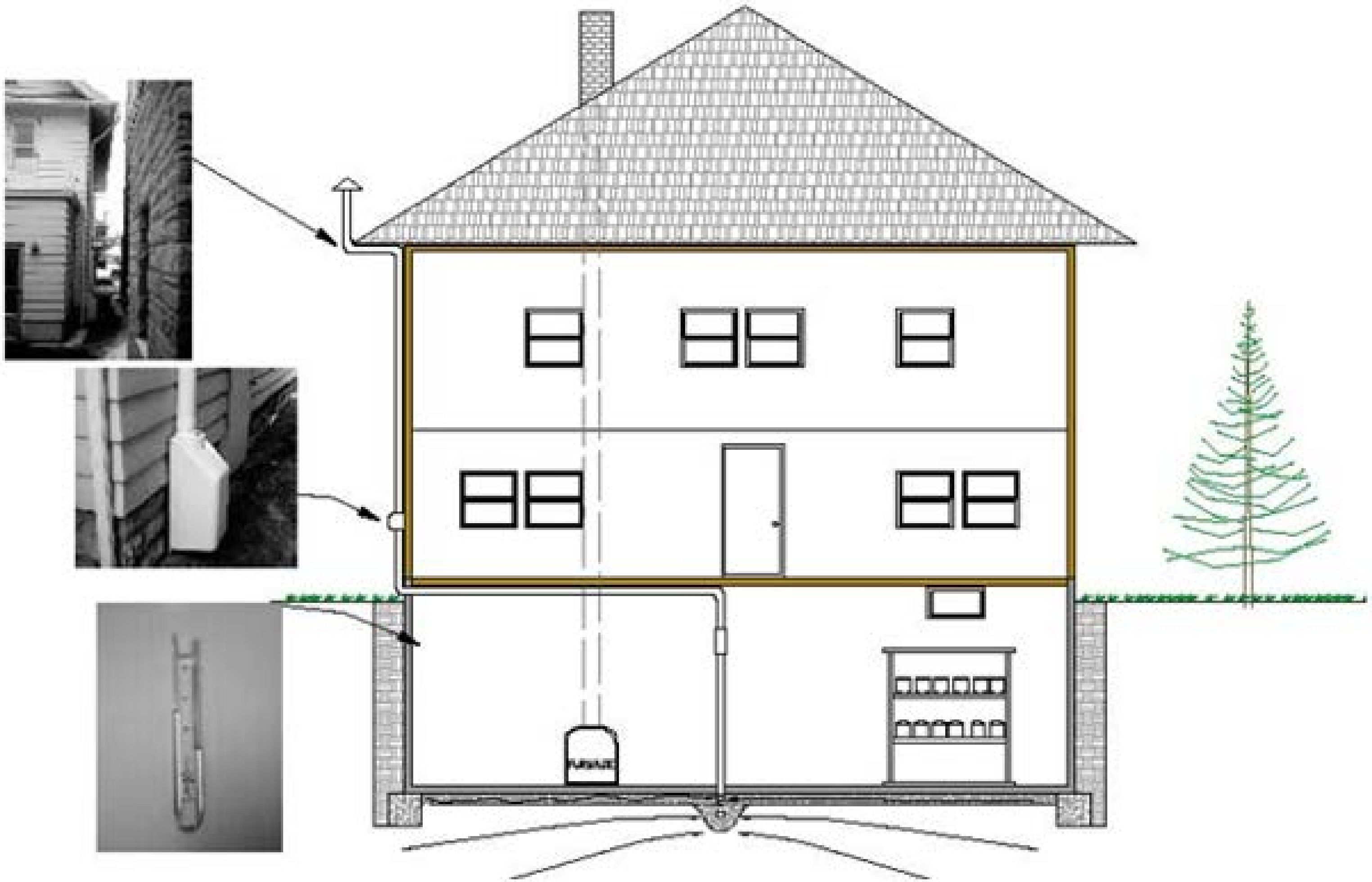
ORD Vapor Intrusion Research Projects Update
John Zimmerman, Alan Williams, and Brian Schumacher Download Presentation Watch Video

Prioritizing Buildings/Zones Using a Quantitative Decision Framework and Incorporating Indicators/Tracers into Vapor Intrusion Building Assessments
Keri Hallberg, Loren Lund, Chris Lutes, Laurent Levy, Donna Caldwell, Travis Lewis, and Teresie Walker Download Presentation Watch Video

Panel Discussion: Do we have a better way of site assessment and site management?
Moderated by Alana Lee Watch Video

Examples of Spatial Variability in Indoor Radon Concentrations in Multifamily and Large Building Project Sites / Overview of IDOH Mitigation Compliance Inspection Pilot Program
Kyle Hoylman Watch Video

Residential VI Mitigation



VI Mitigation Decision Matrix – NJ Example

IARS = Indoor Air Remediation Standard

SGSL = Soil Gas Screening Level

		Indoor Air Concentrations (for COCs)	
		<IARS	>IARS
Sub-Slab Soil Gas Concentrations (for COCs)	<SGSL	No Action	No Action* (if no other subsurface source
	>SGSL to 10X SGSL	Monitor**	Mitigate
	>10X SGSL	Monitor / Mitigate	Mitigate

Notes:

* Investigator should consider the potential for vadose zone (soil) contamination and/or preferential pathways as part of the assessment of vapor intrusion before concluding "no further action"

** Refer to Table 6-2

NJ VI Guidance, 2021

VI Mitigation Decision Matrix – NY Example

Soil Vapor/Indoor Air Matrix A

May 2017

Analytes Assigned:
Trichloroethene (TCE), *cis*-1,2-Dichloroethene (c12-DCE), 1,1-Dichloroethene (11-DCE), Carbon Tetrachloride

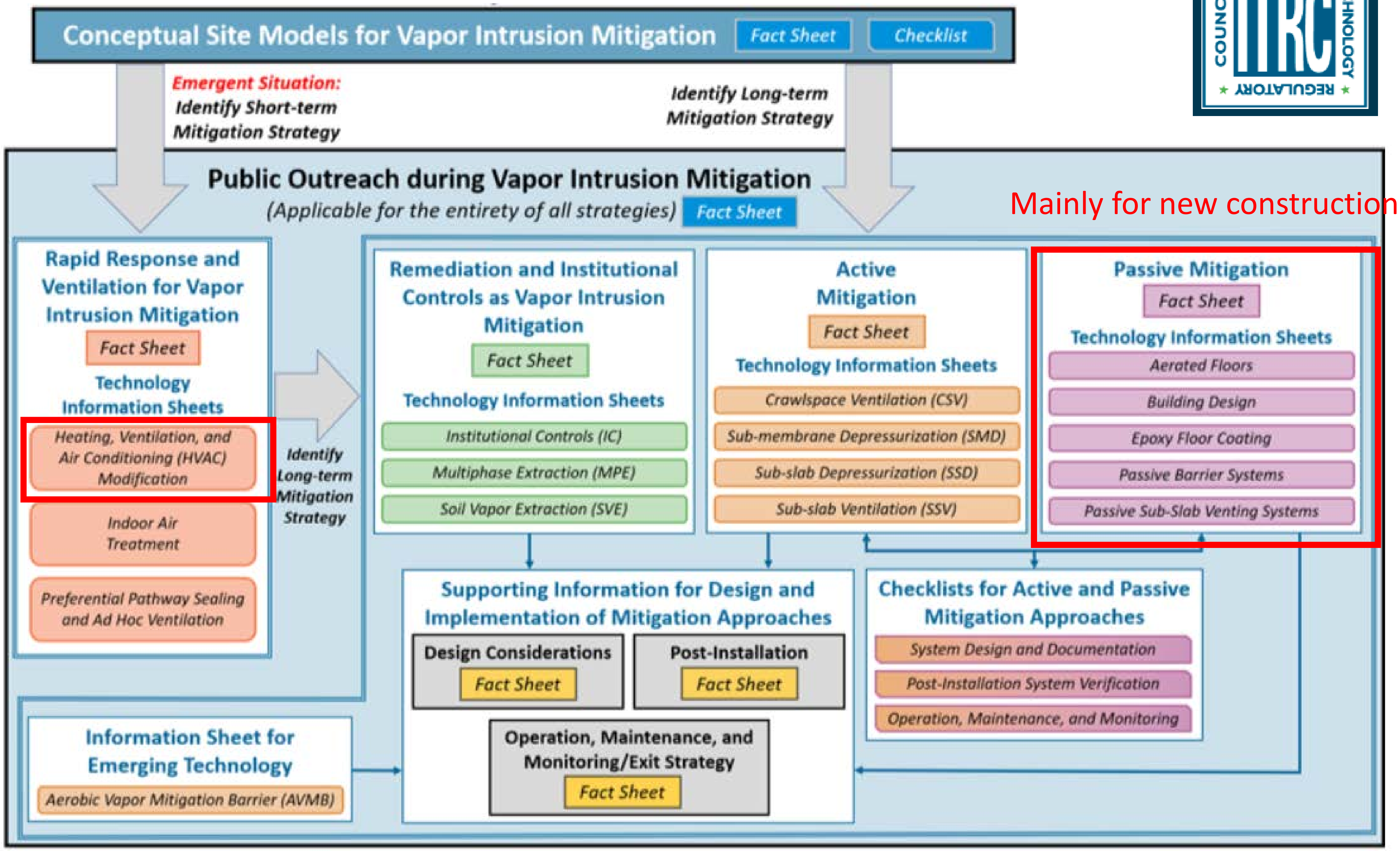
	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m³)		
SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m³)	< 0.2	0.2 to < 1	1 and above
< 6	1. No further action	2. No Further Action	3. IDENTIFY SOURCE(S) and RESAMPLE or MITIGATE
6 to < 60	4. No further action	5. MONITOR	6. MITIGATE
60 and above	7. MITIGATE	8. MITIGATE	9. MITIGATE

Matrix B: Tetrachloroethene (PCE), 1,1,1-Trichloroethane (111-TCA), Methylene Chloride
Matrix C: Vinyl chloride

NY VI Guidance, 2017

VI Mitigation Overview – ITRC Guidance

Mainly for commercial, industrial, institutional buildings



Mainly for new construction

https://vim-1.itrcweb.org/

VI Mitigation – Rapid Response

Penetration/pathway sealing

- Quick, relatively easy, relatively inexpensive
- Some penetrations may not be visible or accessible
- May not be sufficient on its own to achieve target levels
- Supplementary/complementary to active SSD system

Open floor sump

Floor cracks/joints sealed with sealant or caulk

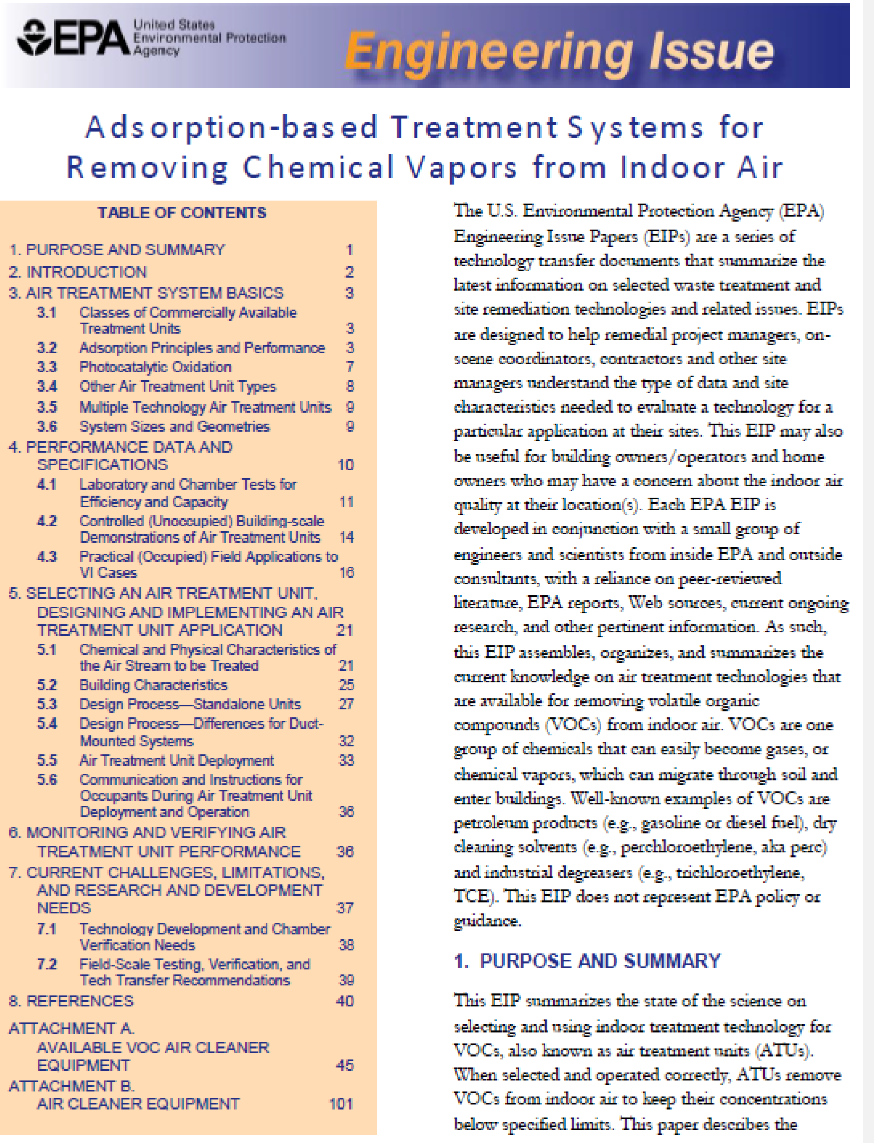
Utility penetration sealed with spray foam

Covered sump with vent and discharge pipes (from VT VI Guidance)

VI Mitigation – Rapid Response

Air treatment units/air purifying units (ATUs/APUs) – Key characteristics

- Versatile and easy to implement
- Actively circulate indoor air and remove VOCs
- Limited and highly variable effectiveness (25% to 99% removal efficiency)
- Effectiveness at very low VOC levels is not well understood/documented
- Adsorption media (GAC) may need to be replaced if operated for months
- Make some noise and require power
- Cost ~ $1,000 to $2,000 each



EPA United States Environmental Protection Agency

Engineering Issue

Adsorption-based Treatment Systems for Removing Chemical Vapors from Indoor Air

TABLE OF CONTENTS

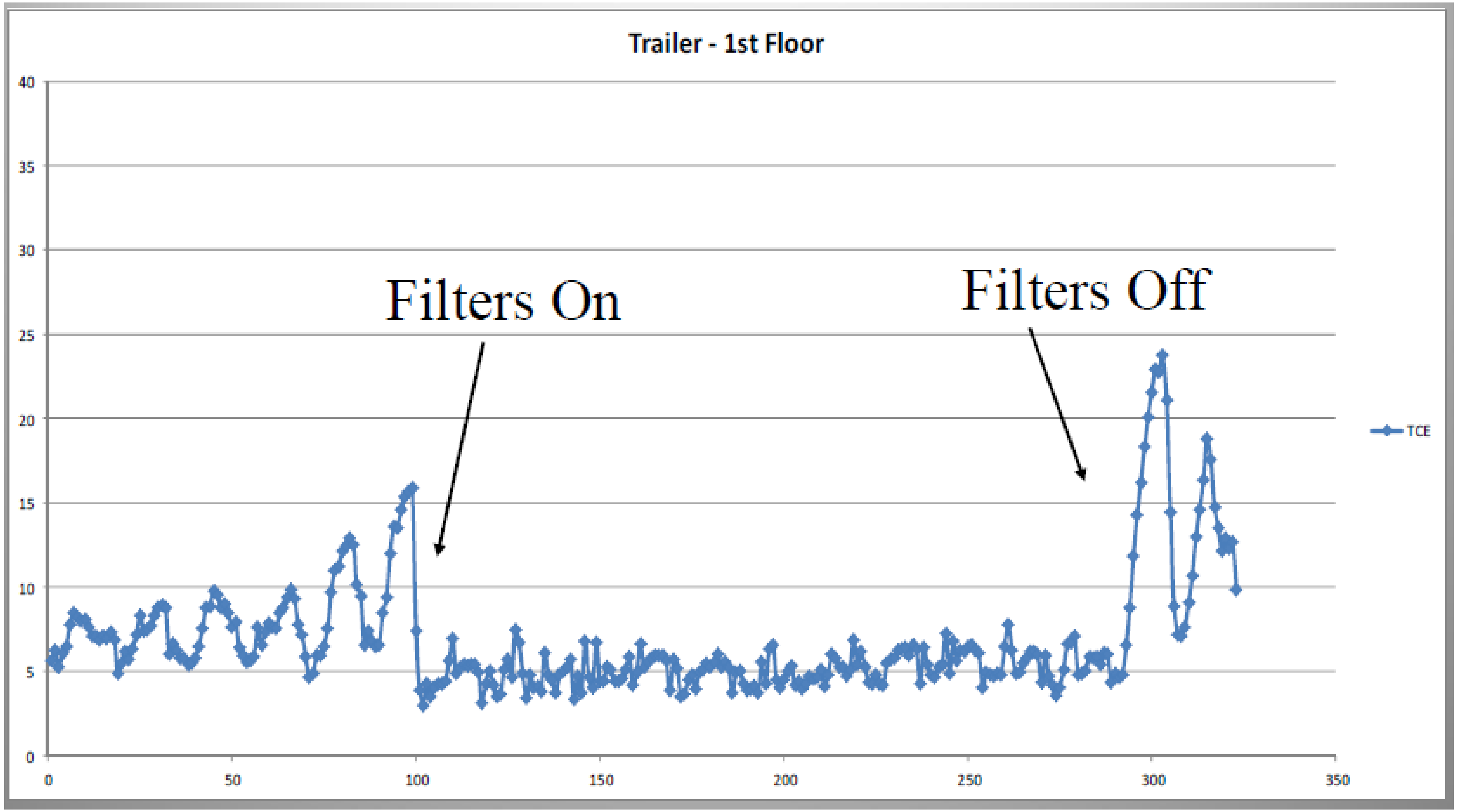
The U.S. Environmental Protection Agency (EPA) Engineering Issue Papers (EIPs) are a series of technology transfer documents that summarize the latest information on selected waste treatment and site remediation technologies and related issues. EIPs are designed to help remedial project managers, on-scene coordinators, contractors and other site managers understand the type of data and site characteristics needed to evaluate a technology for a particular application at their sites. This EIP may also be useful for building owners/operators and home owners who may have a concern about the indoor air quality at their location(s). Each EPA EIP is developed in conjunction with a small group of engineers and scientists from inside EPA and outside consultants, with a reliance on peer-reviewed literature, EPA reports, Web sources, current ongoing research, and other pertinent information. As such, this EIP assembles, organizes, and summarizes the current knowledge on air treatment technologies that are available for removing volatile organic compounds (VOCs) from indoor air. VOCs are one group of chemicals that can easily become gases, or chemical vapors, which can migrate through soil and enter buildings. Well-known examples of VOCs are petroleum products (e.g., gasoline or diesel fuel), dry cleaning solvents (e.g., perchloroethylene, aka perc) and industrial degreasers (e.g., trichloroethylene, TCE). This EIP does not represent EPA policy or guidance.

1. PURPOSE AND SUMMARY

This EIP summarizes the state of the science on selecting and using indoor treatment technology for VOCs, also known as air treatment units (ATUs). When selected and operated correctly, ATUs remove VOCs from indoor air to keep their concentrations below specified limits. This paper describes the

https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NERL&dirEntryId=337835

Example of Air Treatment for Rapid Response

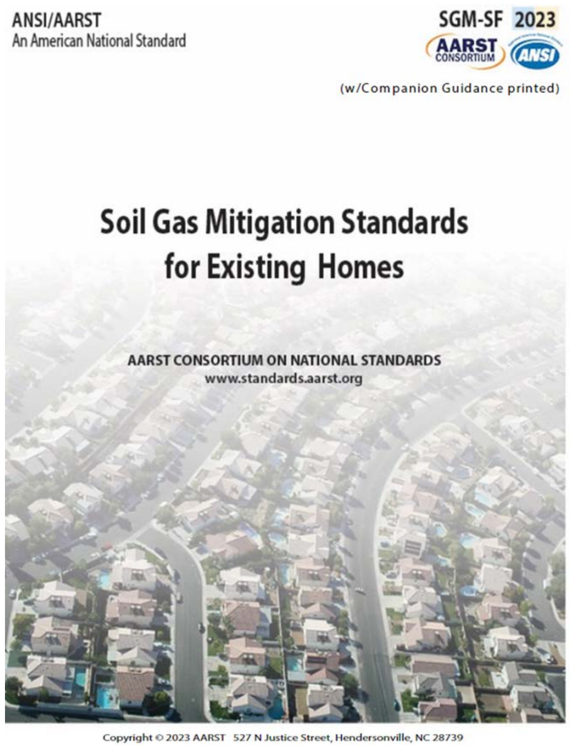


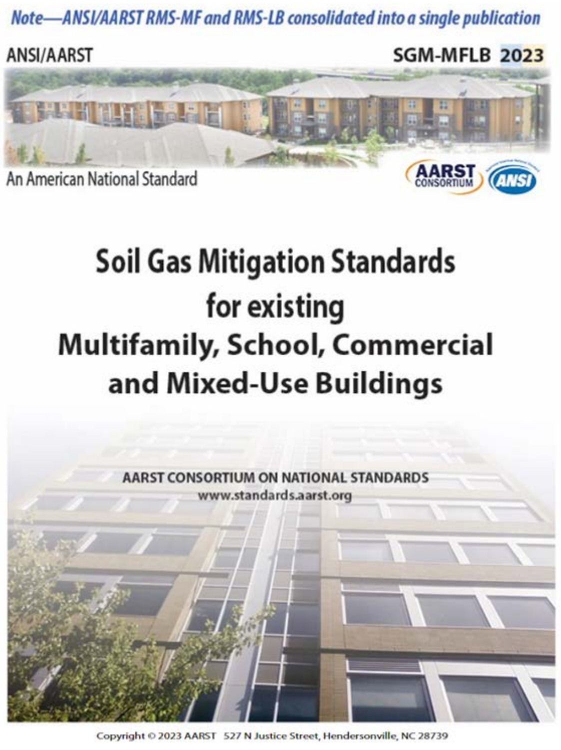
HARTMAN
ENVIRONMENTAL GEOSCIENCE

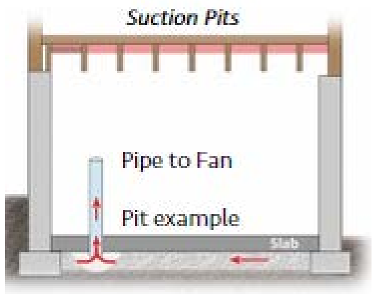
VI Mitigation – Active Mitigation

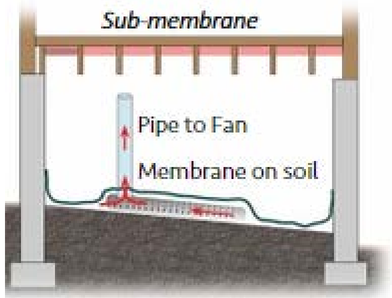
Use an electric-powered fan or blower to collect vapors and discharge them away from a building.

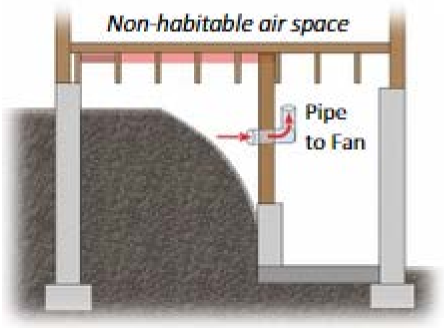
- Sub-Slab Depressurization (SSD) System
- Sub-Slab Ventilation (SSV) System
- Sub-Membrane Depressurization (SMD) System
- Crawlspace Ventilation (CSV)
- Drain Tile Depressurization
- Block Wall Depressurization

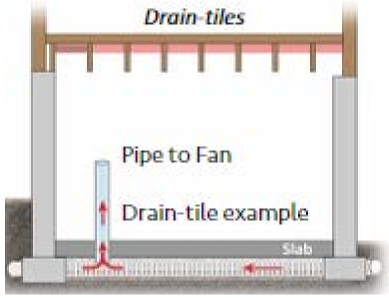


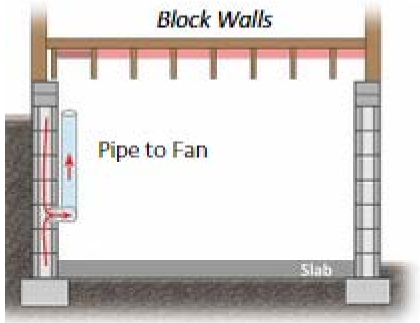












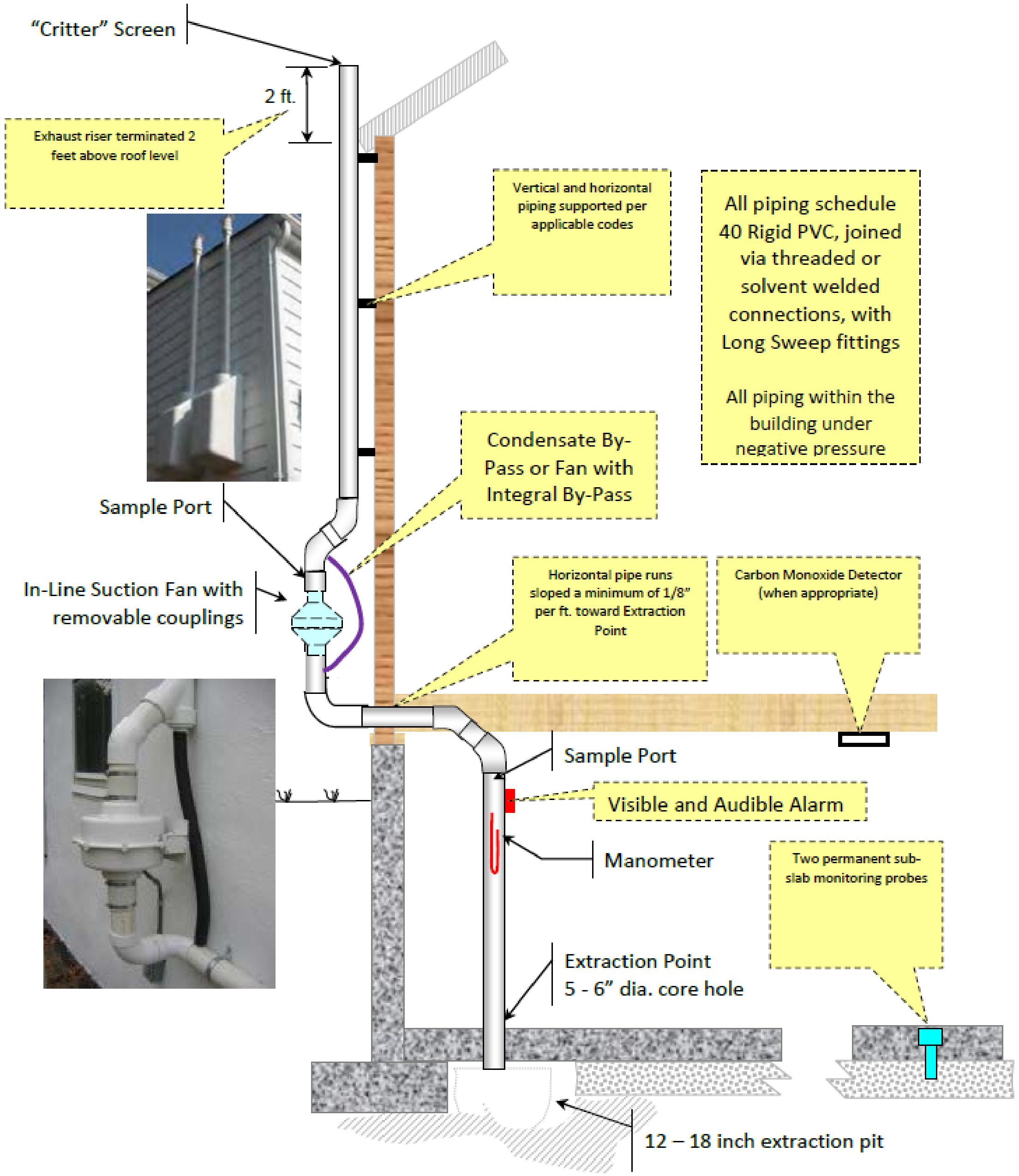
Sub-Slab Depressurization (SSD) System

Key Components

- Suction pit(s)
- Extraction pipe sealed to the floor slab
- Suction fan on outside of building
- System piping with sampling port
- Condensate bypass
- U-tube manometer, vacuum gauge, or pressure sensor
- Exhaust riser to above roof level and away from windows and air intakes
- Sub-slab monitoring points for vacuum verification
- Remote telemetry to alert owner/operator/regulator of system malfunction (MassDEP requirement)

Key Design Considerations

- Building survey to identify pathways/penetrations for sealing
- Groundwater depth
- Diagnostic testing for negative pressure (vacuum) field extension below slab/foundation to determine number of extraction points
- Back-draft evaluation for combustion gas spillage/leakage
- No positive pressure pipe or fans inside occupied space

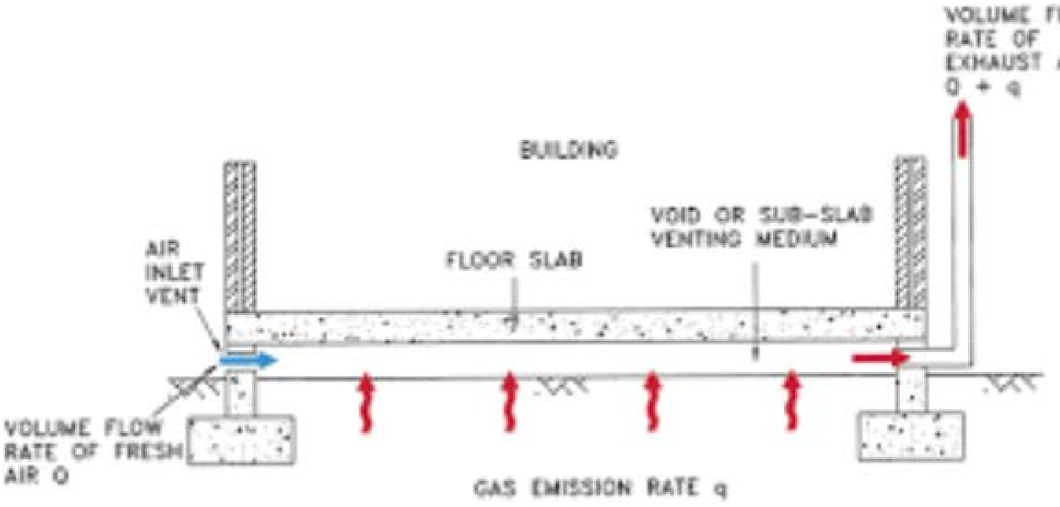


MassDEP VI Guidance, Fig 7, 2016

SANBORN HEAD

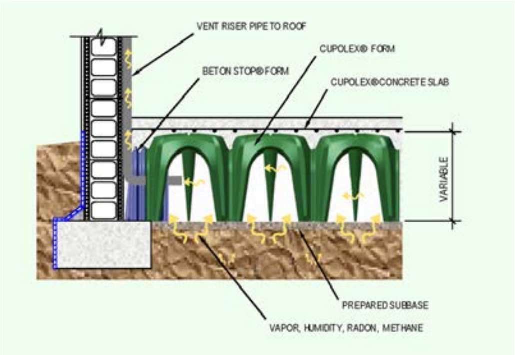
Sub-Slab Ventilation

Different from SSD in that the objective is to sweep the air from below the slab to reduce the concentrations below the slab (high flow, low vacuum) – requires relatively high permeability material below the slab.

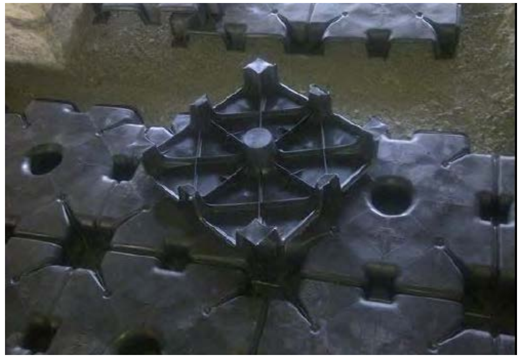


ACS Lining Ltd.

Aerated Floors – used to create open void space below the slab

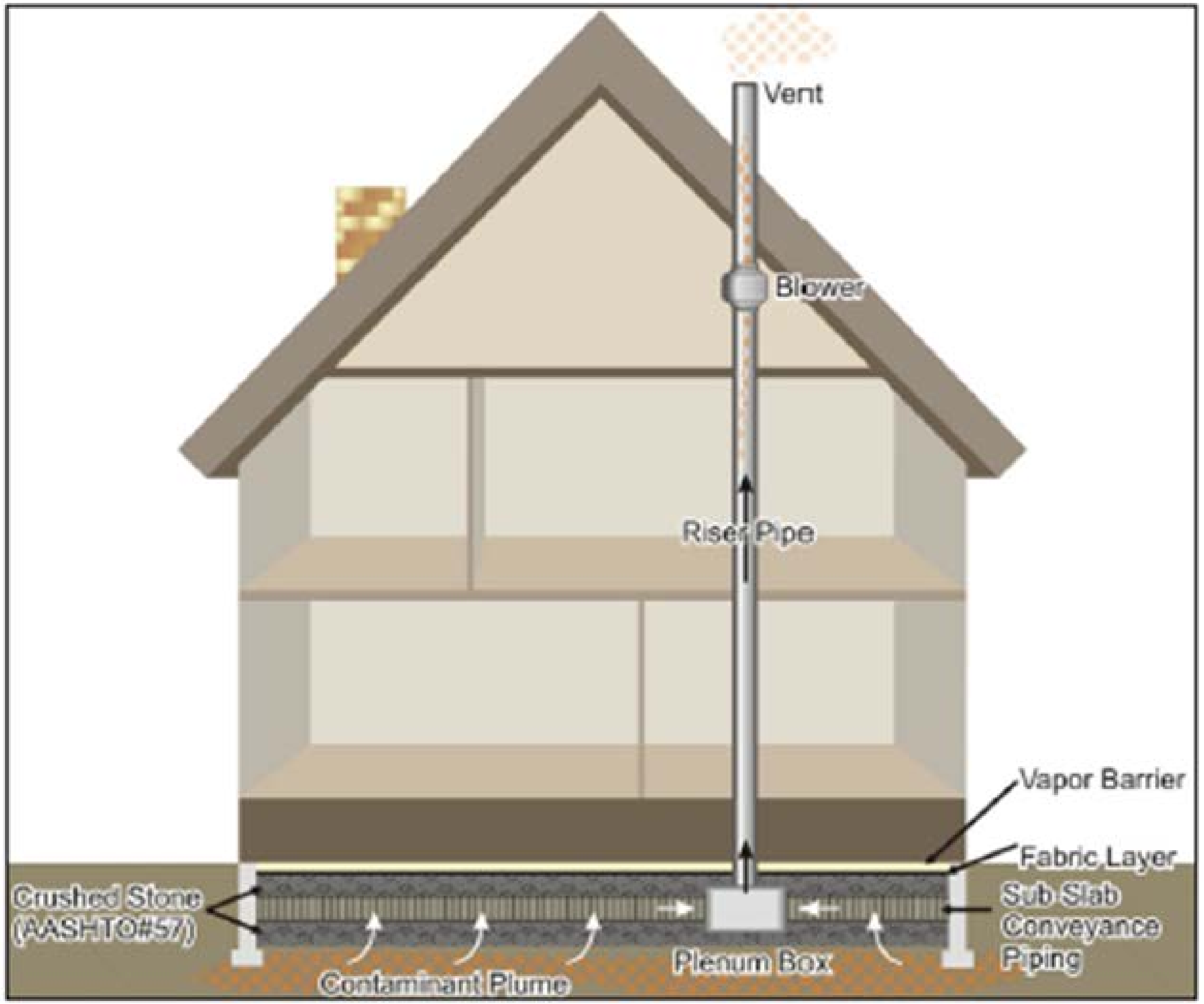


New building (Cupolex forms)



Existing building (from VT VI Guidance)

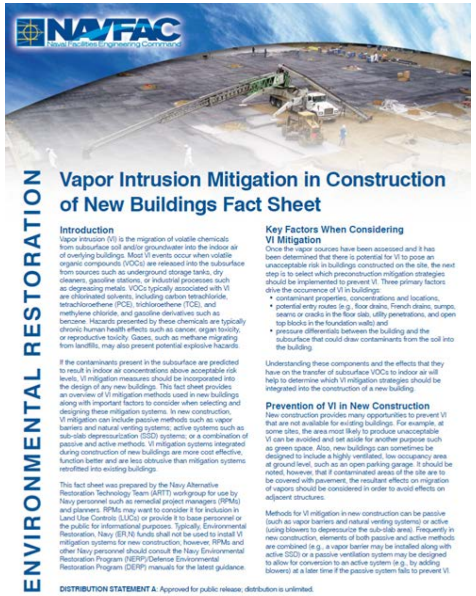
VI Mitigation for New Residential Construction – Design Guidance

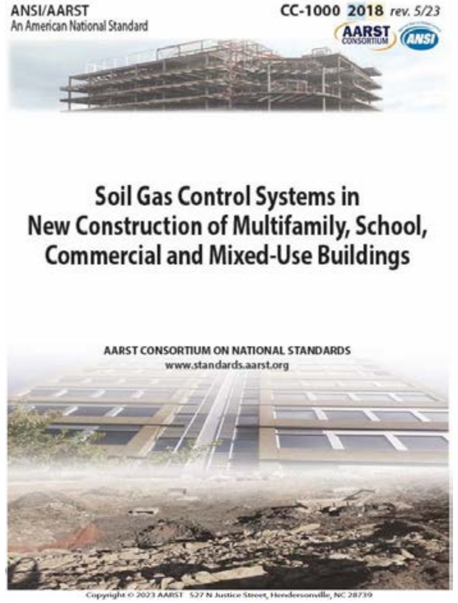


NAVFAC, Fig 1

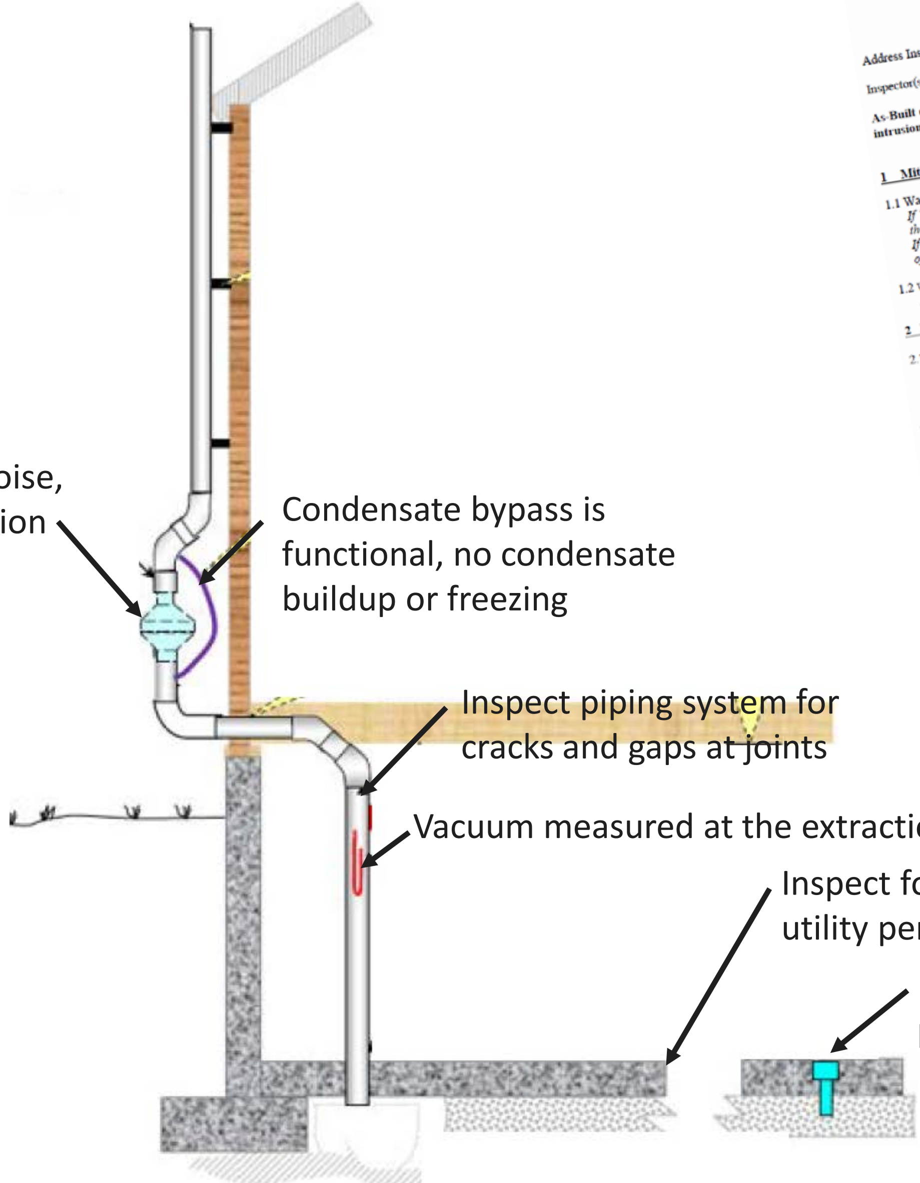
Key components of VI mitigation for new residential construction:

- Permeable sub-slab support material (e.g. gravel)
- Venting all sub-slab areas below occupied spaces
- Properly sized sub-slab and riser pipes
- A sealed vapor barrier
- Properly sized blower to maintain sufficient vacuum below the slab

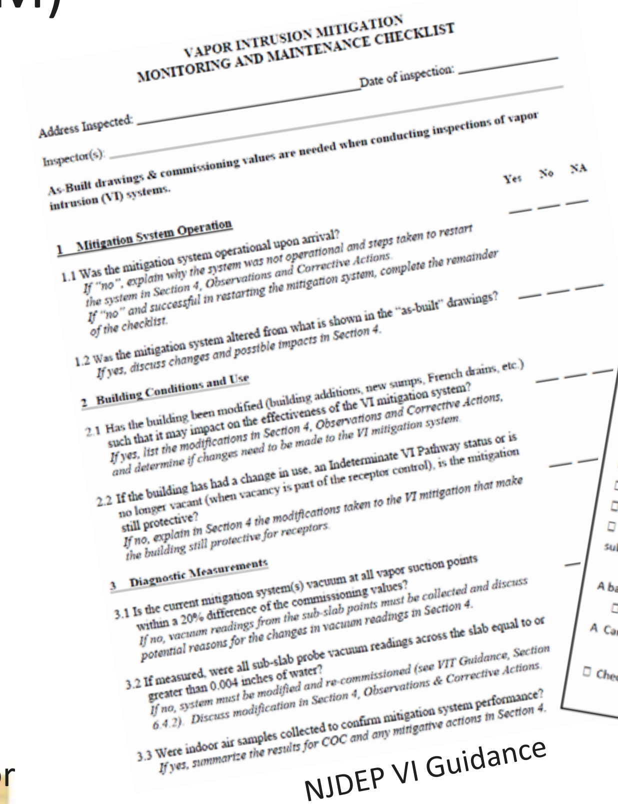

NAVFAC
Naval Facilities Engineering Command
ENVIRONMENTAL RESTORATION
Vapor Intrusion Mitigation in Construction of New Buildings Fact Sheet
Introduction
Key Factors When Considering VI Mitigation
Prevention of VI in New Construction
DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.



VI Mitigation Monitoring and Maintenance (M&M)



Use a Checklist



VAPOR INTRUSION MITIGATION
MONITORING AND MAINTENANCE CHECKLIST

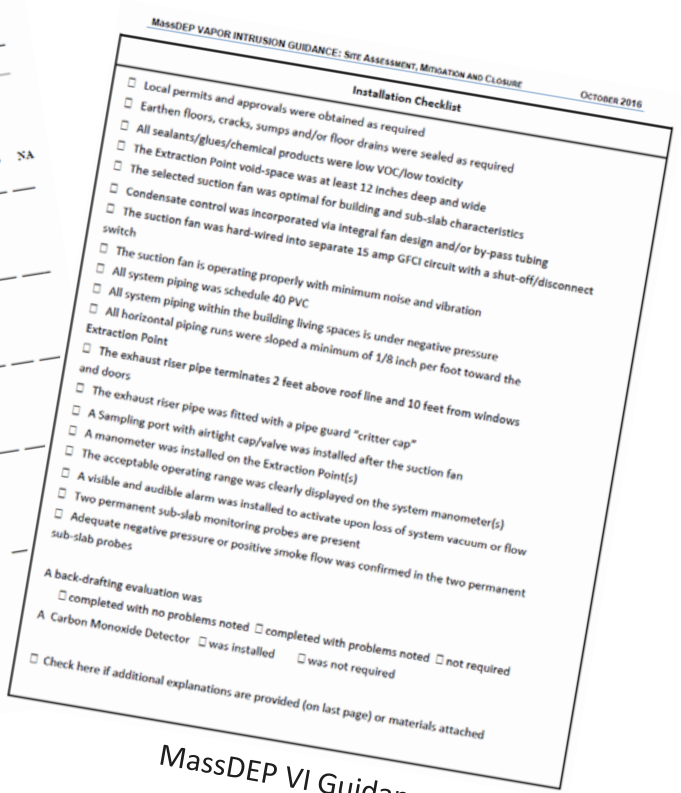
Address Inspected: ____ Date of inspection: ____

Inspector(s): ____

As-Built drawings & commissioning values are needed when conducting inspections of vapor intrusion (VI) systems.

	Yes	No	NA
1 Mitigation System Operation			
1.1 Was the mitigation system operational upon arrival? *If "no", explain why the system was not operational and steps taken to restart the system in Section 4, Observations and Corrective Actions. If "no" and successful in restarting the mitigation system, complete the remainder of the checklist.*			
1.2 Was the mitigation system altered from what is shown in the "as-built" drawings? *If yes, discuss changes and possible impacts in Section 4.*			
2 Building Conditions and Use			
2.1 Has the building been modified (building additions, new sumps, French drains, etc.) such that it may impact on the effectiveness of the VI mitigation system? *If yes, list the modifications in Section 4, Observations and Corrective Actions, and determine if changes need to be made to the VI mitigation system.*			
2.2 If the building has had a change in use, an Indeterminate VI Pathway status or is no longer vacant (when vacancy is part of the receptor control), is the mitigation still protective? *If no, explain in Section 4 the modifications taken to the VI mitigation that make the building still protective for receptors.*			
3 Diagnostic Measurements			
3.1 Is the current mitigation system(s) vacuum at all vapor suction points within a 20% difference of the commissioning values? *If no, vacuum readings from the sub-slab points must be collected and discuss potential reasons for the changes in vacuum readings in Section 4.*			
3.2 If measured, were all sub-slab probe vacuum readings across the slab equal to or greater than 0.004 inches of water? *If no, system must be modified and re-commissioned (see VIT Guidance, Section 6.4.2). Discuss modification in Section 4, Observations & Corrective Actions.*			
3.3 Were indoor air samples collected to confirm mitigation system performance? *If yes, summarize the results for COC and any mitigative actions in Section 4.*			

NJDEP VI Guidance



MassDEP VAPOR INTRUSION GUIDANCE: SITE ASSESSMENT, MITIGATION AND CLOSURE — OCTOBER 2016

Installation Checklist

- ☐ Local permits and approvals were obtained as required
- ☐ Earthen floors, cracks, sumps and/or floor drains were sealed as required
- ☐ All sealants/glues/chemical products were low VOC/low toxicity
- ☐ The Extraction Point void-space was at least 12 inches deep and wide
- ☐ The selected suction fan was optimal for building and sub-slab characteristics
- ☐ Condensate control was incorporated via integral fan design and/or by-pass tubing
- ☐ The suction fan was hard-wired into separate 15 amp GFCI circuit with a shut-off/disconnect switch
- ☐ The suction fan is operating properly with minimum noise and vibration
- ☐ All system piping was schedule 40 PVC
- ☐ All system piping within the building living spaces is under negative pressure
- ☐ All horizontal piping runs were sloped a minimum of 1/8 inch per foot toward the Extraction Point
- ☐ The exhaust riser pipe terminates 2 feet above roof line and 10 feet from windows and doors
- ☐ The exhaust riser pipe was fitted with a pipe guard "critter cap"
- ☐ A Sampling port with airtight cap/valve was installed after the suction fan
- ☐ A manometer was installed on the Extraction Point(s)
- ☐ The acceptable operating range was clearly displayed on the system manometer(s)
- ☐ A visible and audible alarm was installed to activate upon loss of system vacuum or flow
- ☐ Two permanent sub-slab monitoring probes are present
- ☐ Adequate negative pressure or positive smoke flow was confirmed in the two permanent sub-slab probes

A back-drafting evaluation was ☐ completed with no problems noted ☐ completed with problems noted ☐ not required

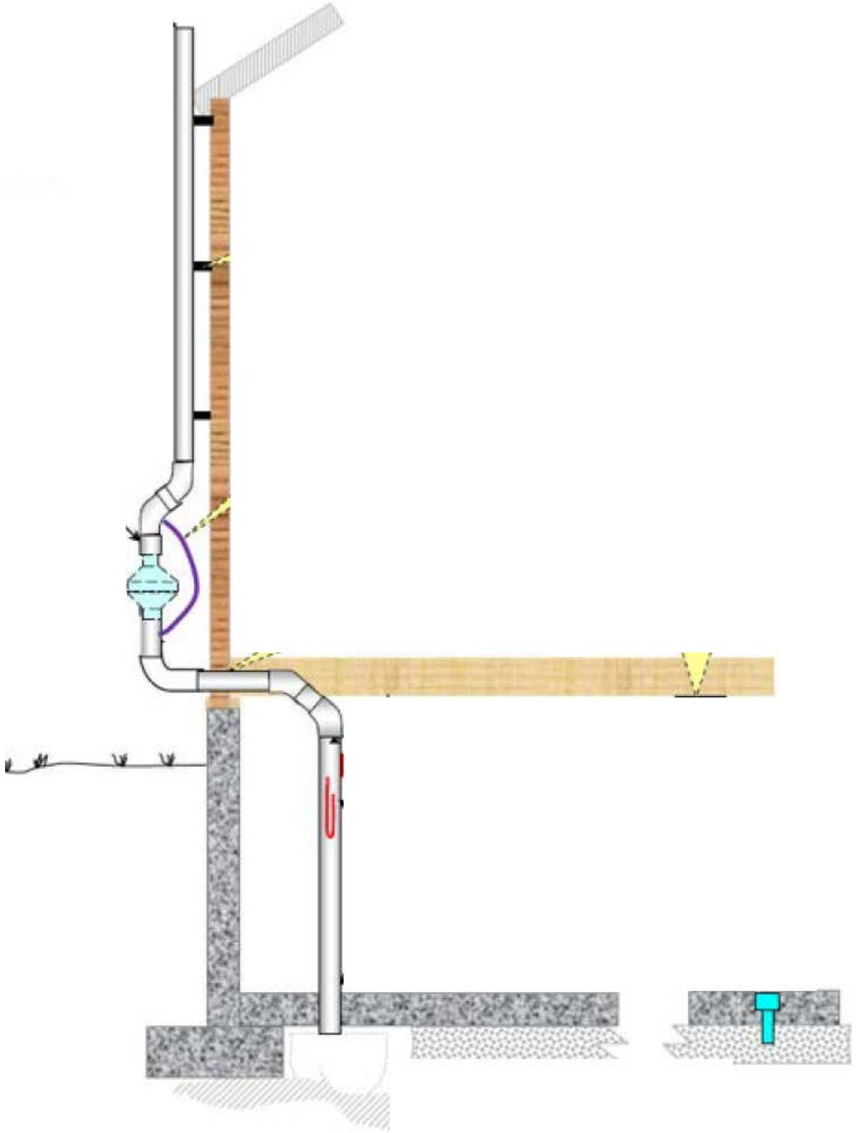
A Carbon Monoxide Detector ☐ was installed ☐ was not required

☐ Check here if additional explanations are provided (on last page) or materials attached

MassDEP VI Guidance

*For active systems, indoor air sampling is not typically needed unless conditions change from those established at commissioning

VI Mitigation Monitoring and Maintenance (M&M) - should be conducted at least annually



from NJDEP VI Guidance Table 6-1

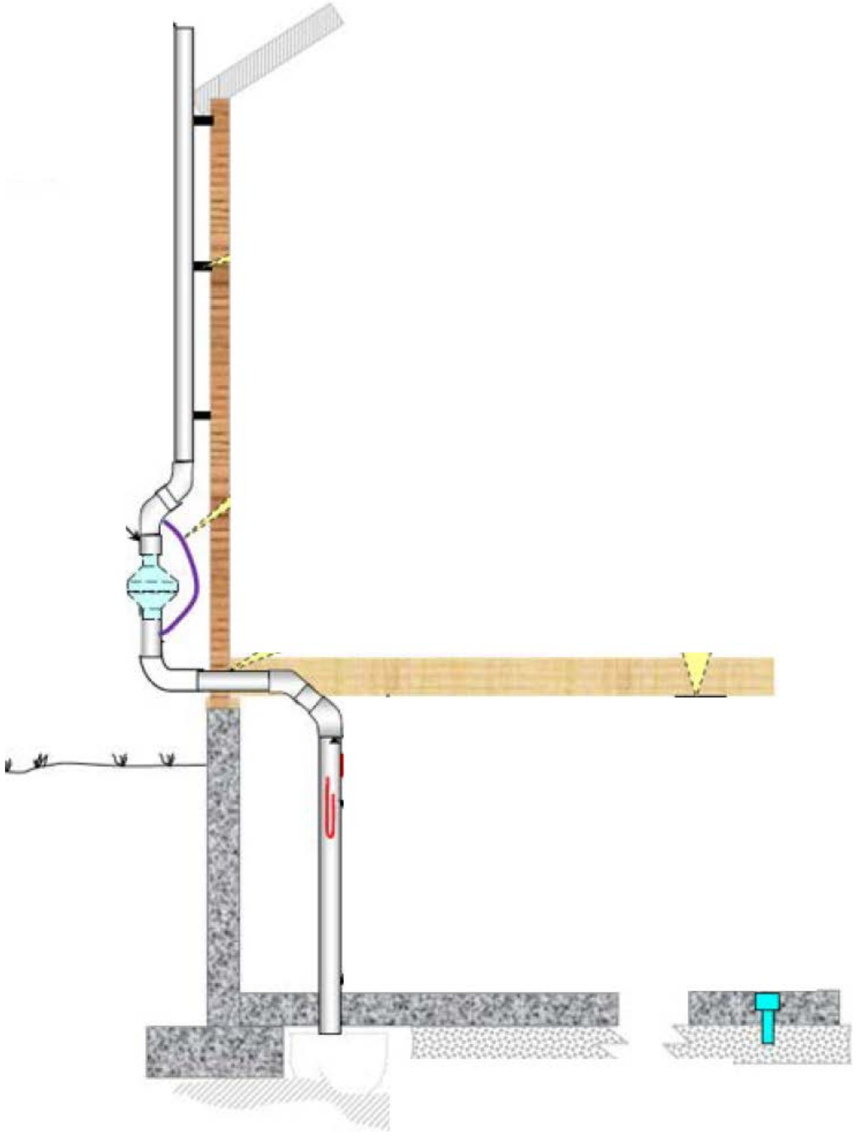
	Active SSDS or SSVS	Passive SSDS or SSVS
M&M	**First year M&M:** 1) Semi-annual inspection of system[3] 2) Verify the commissioning values[3] **Second year M&M & beyond:** 1) Annual inspection of system[3] 2) Annual collection of appropriate system diagnostic measurements and verify consistency[3] with baseline values	**First year M&M:** 1) Semi-annual system[3] inspection 2) Sampling of IA and SSSG during heating season[1] following VS sampling **Second year and beyond:** 1) Annual inspection of system[3] 2) IA (or void space) sampling during heating season[1] every year until results are consistently below IARS; THEN 3) IA sampling during the heating season every 5 years

1 – "Heating season" is from November 1 to March 31.

3 – For systems that are larger, and a greater complexity, may require a greater frequency of inspections.

*For active systems, indoor air sampling is not typically needed unless conditions change from those established at commissioning

VI Mitigation Termination Evaluation

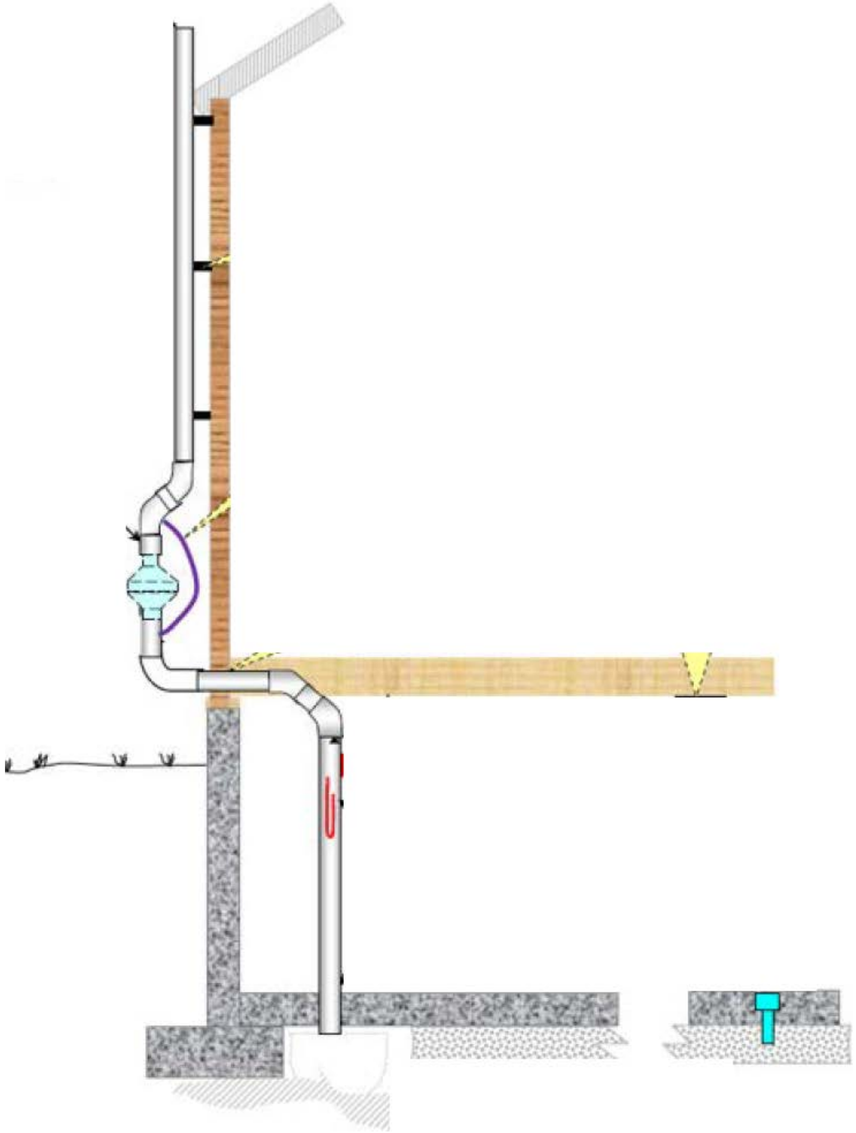


1. Evidence of remediation of subsurface vapor source.
2. Shut down VI mitigation system temporarily.
3. Conduct attainment period, or rebound, monitoring.

Criteria	Massachusetts	New Jersey	New York
Shutdown period	7 days minimum	30 days minimum	Requires site-specific work plan
Sampling requirements	Indoor air	Indoor air and sub-slab soil gas	Indoor air and sub-slab soil gas
# of sampling events	Three: spaced over 2 years; at least one in heating season, and one other "worst-case" event (high gw table)	Two: spaced at least 4 months apart; one in heating season	Demonstrate no "rebound" effect when system is off for prolonged period – site-specific determination
Other conditions	Run system between sampling events	Run system between sampling events	No rebound when system is off for "prolonged" period

Refer to state VI guidance documents for further details

Closing Points/Summary



VI Assessment
- Develop the conceptual site model – establish if and how subsurface vapors might be causing vapor intrusion.
- Consult with the VI guidance in your state.

Use VI Investigation Toolbox
- Traditional sampling methods for soil gas and indoor air
- Real-time monitoring
- Building pressure control
- Long-term passive samples
- Guided samples

VI Mitigation
- Consider need for rapid response actions
- Conduct building survey and diagnostic/design testing for active mitigation
- Use available and recognized design standards and guidance
- Implement regular monitoring and maintenance (M&M) program
- Consider termination criteria when appropriate

Thank you! Questions?