ASTSWMO Annual Meeting

Vapor Intrusion Training
October 18, 2012
ITRC – Shaping the Future of Regulatory Acceptance

- Host organization
- Network
  - State regulators
    - All 50 states and DC
  - Federal partners
  - ITRC Industry Program
- Academia
- Community stakeholders
- Wide variety of topics
  - Technologies
  - Approaches
  - Contaminants
  - Sites
- Products
  - Documents
    - Technical and regulatory guidance documents
    - Technology overviews
    - Case studies
  - Training
    - Internet-based
    - Classroom
Diversity of the ITRC VI Team

- Team Composition
  - 32 state regulators
  - 31 consultants
  - 10 federal representatives
  - 13 vendors and industry reps
  - 2 community stakeholders

A large majority of the international vapor intrusion experts participated on the ITRC’s VI team at some point over its three year history.
Basis of the Training
Vapor Intrusion

- Introduction to VI Pathway
- Investigative Approaches
- Investigative Tools
- Data Review and Background Evaluation
- Mitigation
Introduction to VI Pathway

Key Topics

- Definition of vapor intrusion
- Technical basics
- Special influences
- Community issues
Vapor Intrusion

The migration of volatile chemicals from the subsurface into overlying buildings (USEPA 2002a)
What Is a VI Compound?

- Compounds of concern
  - Volatile organics
  - Semi-volatile organics
    - i.e., naphthalene
  - Mercury
  - PCBs
  - Dioxins
- USEPA VI Guidance identifies 114 compounds
- State guidance varies in number of compounds
Vapor Pathway into Structures

- Partitioning to vapor phase
- Diffusion in vadose zone
- Advection near building
- Dilution in building
Contaminant Partitioning

Partitioning
– the distribution of molecules between different phases

Partition Coefficient - Henry’s Constant (H)
– the ratio of the concentration in soil gas \( C_{sg} \) to the concentration in groundwater \( C_{gw} \)

\[
C_{sg} = C_{w} \times H
\]

\[
H_{benzene} = 0.25
\]

GW Conc = 10 µg/L

\[
C_{sg} = 10 \times 0.25 = 2.5 \text{ µg/L}
\]
Diffusion

- movement (flux) of molecules in a stagnant phase from a high concentration to a low concentration
Advection

- **Pressure gradient**
  - Wind speed
  - Barometric pressure changes
  - HVAC (Heating, ventilation, air conditioning) and fan operations
  - Stack effect
Factors Affecting Movement in the Vapor Phase

**Rainfall** - Infiltration may displace soil-gas containing VOCs (volatile organic compounds) to dryer soil underneath a building and prevent mass loss to the atmosphere.

**Temperature** - Higher indoor temperature compared to outdoor temperature may create a “stack” effect.

**Wind and Barometric Fluctuation** - Inside pressure relative to outside pressure.

Source: Figures from Massachusetts DEP
Building Design and Ventilation

- Air exchange rate - the rate at which outdoor air replaces indoor air
  - HVAC
  - Ventilation
    - Exhaust pollutants from a fixed source
    - Dilute pollutants from all sources within a space
Attenuation (Alpha) Factors

\[ \alpha_{sg} = \frac{C_{\text{indoor}}}{C_{sg}} \quad \text{for soil gas to indoor air} \]

\[ \alpha_{gw} = \frac{C_{\text{indoor}}}{(C_{gw} \cdot H)} \quad \text{for groundwater to indoor air} \]

Attenuation Factor Example

\[ \alpha_{sg} = \frac{C_{\text{indoor}}}{C_{sg}} \]

Alpha = 10/500

Alpha = 0.02 (shallow soil gas)

Indoor Air
10 \( \mu g/m^3 \)

500 \( \mu g/m^3 \) Soil Gas (shallow)
Special Influences on VI

- Indoor air background sources
- Biodegradation
- Preferential pathways
- Land use
Indoor Air Background


Addressing Background Sources

- Define contaminants of concern (COC)
- Conduct building surveys
  - See Appendix G. VI-1
- Utilize background databases
- Collect sub-slab soil gas samples
- Collect ambient (outdoor) air samples
- Data Validation
- Data review
Biodegradation

Biodegradable Petroleum Hydrocarbon Volatile Chemicals of Concern (PH-VCoC) are

“petroleum hydrocarbons such as benzene, xylenes, toluene and ethylbenzene (or a mixture of such chemicals) that are a subset of volatile chemicals of concern and that are distinguished because they are known to readily biodegrade to carbon dioxide in the presence of oxygen by ubiquitous soil microbes.”

ASTM (E2600-08)
What are preferential pathways, and when are they significant?

- Site conditions that result in significant lateral transport, enhanced convective flow
  - Large subsurface utilities (e.g. storm drains)
  - Basement sumps
  - Elevator shafts

VI Guideline p. 8
Land Use

- Developed vs. future use
- Commercial vs. residential
- Institutional restrictions
- Sensitive populations
Community Outreach

- Sensitive topic in community
- Strong community outreach helps inform and prepare
- Working with community groups
- Communication strategies
VI Investigative Approach

Key Topics

- Site-specific features affecting VI
- Multiple lines of evidence (MLEs)
- Conceptual site models (CSMs)
Site-Specific Features

- **Source**
  - Degradable vs. non-degradable
  - VOCs vs. SVOCs
  - Vadose zone vs. groundwater
  - NAPL or not

- **Pathway**
  - Diffusion vs. advection dominated
  - Barriers: wet clay-rich layers, freshwater lens
  - Preferential pathways: high-K fill, openings in building envelope

- **Receptor**
  - Building pressure/vacuum, ventilation rates
  - Interior sources (background)
  - Sensitive populations
Multiple Lines of Evidence (MLE)

- Chemistry
- Soil properties
- Degradation
- Other
  - Weather data
  - Gas pump tests
  - HVAC monitoring
  - Building pressure manipulation
MLE: Chemistry

Groundwater

External Soil Gas

Near-Slab Soil Gas

Sub-Slab Soil Gas

Indoor Air

Outdoor Air

VI Guideline Appendix D
MLE: Soil Properties

Coring and Visual Inspection

Particle Size Distribution

Flow, Vacuum, and Permeability

Porosity and Moisture Content
MLE: Degradation

Field Screening for O₂ and CO₂

Vertical Profiles of O₂ and CO₂

Flux

Increasing depth

Clean soil

O₂

CO₂

VOCs

Soil surface
MLE: Other

- Weather
- Gas Pump Tests
- HVAC Monitoring
- Building Ventilation
- Building Pressure Manipulation

Soil Gas Pressure over Time

Pressure/Ventilation Testing
Conceptual Site Model (CSM)

- Simplified version (pictures and/or descriptions) of a complex real-world system that approximates its relationships
Components of a CSM

- Underground utilities and pipes
- Existing and potential future buildings
- Construction of buildings
- Type of HVAC system
- Soil stratigraphy
- Hydrogeology and depth to water table
- Receptors present (sensitive?)
- Nature of vapor source
- Vadose zone characteristics
- Limits of source area and contaminants of concern
- Surface cover description in source and surrounding area
Conceptual Site Model

Conceptual Model Scenarios for the Vapor Intrusion Pathway  (EPA February 2012)

CSM for Petroleum Vapors

- Gas Station Building
- UST
- LNAPL & contaminated soil
- Dissolved contamination
- Strong vapor source from LNAPL & contaminated soil
- Clean aerobic soil
- Weak Vapor Source from Dissolved Plume
- HENRY'S LAW CONSTANT
Investigative Approach

- Existing data suggest $O_2$ effective barrier
- Attenuation $>10,000$ times
- Document by vertical profiles of contaminants of concern and $O_2$
Benzene: Soil Gas & Dissolved GW Paired Measurements

5 ft clean overlying soil attenuates vapors associated with dissolved Benzene <=1,000 ug/L

Slide courtesy of Robin Davis, Utah DEP
Chlorinated VOCs in GW

- Stack effect
- Diffusion through vadose zone
- Volatilization from water table

Source

Geosyntec Consultants
Fresh-Water Lens

- Assess off-gassing with combined shallow GW and deep soil gas samples
- Map “extent” in soil gas before selecting buildings for intrusive samples

Rainfall

“clean” soil

“clean” groundwater

Source
Geologic Barrier

- Soil cores to assess stratigraphy, soil texture, porosity, and moisture content
- Document lateral extent of barrier
- Vertical profiles of soil gas concentrations in select locations
Chlorinated VOCs in Vadose Zone

- Calculate “expected” lateral diffusion profile
- Then collect samples at various distance along the pathway to check consistency
Source Beneath Building

- External data not as useful
- May want to consider SVE if concentrations are >> screening levels
- Assess spatial distribution in sub-slab concentrations
- Consider indoor air data with changes in HVAC operation
Vacant Lot

- Start with a cost-benefit analysis for soil gas monitoring program vs. proactive mitigation
  - Avoidance: build away from areas of suspected VOCs
  - Passive barrier (visqueen, HDPE, spray tars)
  - Passive venting (gravel layer and wind-turbines)
  - Passive barrier plus passive venting (option to go active)
  - Intrinsically safe design (podium construction)
Summary

- One-size doesn’t fit all – customize to site-specific conditions
  - Let the science lead the logic
- Decide in advance what you expect the data to show
  - Consistency supports the conceptual site model
- Map out a plan for anticipated and potential outcomes
- Concentrations are not the only lines of evidence
Investigative Tools

Key Topics

- Interior versus Exterior
- Groundwater
- Soil
- Indoor Air
- Soil Gas
- Modeling
“Interior” Investigations

- Public relations
  - Access agreements, fact sheets, meetings
- Removal of interior sources (if practical)
- Samples and “controls”
  - Outdoor, sub-slab, etc.
- Analytical methods, analytes, reporting limits
- Risk communication
- Potential litigation
“Exterior” Investigations

- “Map” the contamination
- Identify buildings with potential VI risks
- Identify target compounds
- Collect site-specific geologic / pneumatic data
- Minimize inconvenience to occupants / owners
Groundwater Data

- Assess available data
  - Well location and construction
  - Aquifer characteristics
  - Interpolate – flow and direction
- Gather new data
  - Well location, construction, sampling
- Consider perched water, vertical profiles
- Incorporate long-term monitoring

VI Guideline p. D-2
Interpreting Soil Data

- Soil data generally not acceptable for VI assessment by most agencies
- Look-up tables rarely exist
- Calculate soil gas concentration from soil data using partitioning equation (easier to use J&E soil spreadsheet to calculate soil gas concentration)

Note: Soil data often under predicts risk
Soil Gas Data

- **Pros**
  - Representative of subsurface processes
  - Measures concentrations in the gas phase
  - Relatively inexpensive
  - Can give real-time results

- **Cons**
  - Attenuation factor is variable
  - Conservative Screening Levels (especially for PHCs)
  - Protocols still debated
Indoor Air Measurement

- **Pros**
  - Actual indoor concentration, no modeling required
  - Relatively quick, no drilling or heavy equipment
  - Less spatial variability than soil vapor

- **Cons**
  - Potential for background sources, typically addressed by:
    - Ambient air and sub-slab vapor samples
    - Survey of building materials and activities
  - No control (sample left unattended for up to 24 hours)
  - Typically more temporal variability than soil vapor
  - Requires entering home multiple times
Indoor Air Sampling

- **Visit #1 – Interview**
  - Conduct survey/inventory, questionnaire, schedule
- **Visit #2 – Drop off canisters**
  - Prepare sketch of home
  - Select canister location(s)
- **Visit #3 – Pick up canisters**
  - Conduct post-test questionnaire
  - Ship canister(s) under COC to laboratory
Indoor Air Sampling

Flow Controller

Summa Canister
Location

- Canister Placement in Homes
  - Basement (if present)
  - First floor
  - Ambient air
- Central living areas preferred
- Away from windows, vents, and doors
- Where they won’t be disturbed
- Avoid
  - Bathrooms
  - Utility/storage rooms
  - Laundry rooms
  - Hobby areas

VI Guideline p. D-22
Sample Collection Issues

- Collection Times
  - Residences: Typically 24 hours
  - Commercial/Industrial: Typically 8 hours
  - Longer Periods? 7 to 30 days?

- How Many Events?
  - More than one?
  - What seasons?
  - Other factors (height of water table?)
Soil Gas Sampling Methods

- Sample collection methods
  - Passive soil gas surveys
  - Active soils gas surveys

Active method most often employed for VI

Refer to:

Regulators Checklist for Reviewing Soil Gas Data,
Appendix F

(ITRC VI-1, 2007)
Passive Soil Gas

- **Pros**
  - Easy to deploy
  - Can find contamination zones
  - Low permeability soils

- **Cons**
  - May not give concentration
  - No less expensive (depending on analysis)

- Currently considered as screening tool

*VI Guideline p. D-16*
Passive Soil Gas Samplers

Adsorbent inside tube open on one end

Adsorbent inside vapor permeable, waterproof membrane

Adsorbent inside badge
Active Soil Gas Sampling

- Considerations
  - Purge and sample volumes
  - Flow rate, vacuum, and leak tests
  - Sample containers
  - Temporal effects
  - Real-time sample and analysis
  - Sample density and locations
Probe Installation Methods

- Driven probe/rod methods
  - Hand equipment, direct-push
- Vapor mini-wells/implants
  - Inexpensive and easy to install/remove
  - Allow repeated sampling

VI Guideline p. D-7,8

USEPA 2002b
Driven Probe/Rod
Vapor Mini-wells/Implants
Multi-Depth Nested Well

1/8” or 1/4” tubing

Wire wrap

Gas inlet perforations

1/8” or 1/4” tubing

Second soil vapor implant

First soil vapor implant

off/on valve

Sand pack

Bentonite grout seal

Sand pack

Diagram courtesy H&P Mobile Geochemistry
Liquids

Gases

Tent Shroud
Liquid Leak Tracer Method

- **Pros**
  - Fast & easy
  - Can cover multiple spots easy
  - Very conservative (100 ug/L = 0.1% leak)

- **Cons**
  - Typically qualitative
  - Don’t know results in real-time without lab
  - Small leak can raise detection limits of VOC analysis

**OK Method if Lab On-site**

*VI Guideline p. D-9*
Gas Leak Tracer Method

- **Pros**
  - Quantitative
  - Real-time results with portable meters

- **Cons**
  - More complicated and slower. Increases costs
  - Harder to cover multiple locations, especially with Direct Push

**Best Method if No Lab On-site**
Soil Gas Sampling for HCs

- Might need multiple depth profiles
  - If deep samples exceed allowable levels
  - Collect shallower soil gas data to document attenuation
- Always collect oxygen data
- Might need soil phase data
Theoretical Bio Profile

- **O₂**
  - **flux**
  - **VOCs**

- **soil surface**
- **increasing depth**
  - **clean soil**
  - **petroleum product**

**VOCs**

**CO₂**
Sub-slab Soil Gas Sampling

- Soil gas most likely to enter structure
  - May detect chemicals originating within building
- May collect indoor air concurrently for comparison
- Sample at slab base and/or at depth
- Permanent or temporary sample points

VI Guideline p. D-17
Sub-Slab vs. Near-Slab Samples
Sub-Slab vs. Near-Slab

- EPA and some states prefer sub-slab
- Very intrusive
- Hydrocarbons: if $O_2$ present, near-slab okay
- Cl-HCs: at source or mid-depth
Get Enough Data

- Soil gas not homogeneous
- Lateral and vertical variations exist
- Don’t chase 1 point anomalies
- Get enough data near/around/under
- On-site analysis/field screening enables real-time decisions to select additional sampling locations
Predictive Modeling

- **Pros**
  - Can use GW, soil, soil gas data
  - Relatively easy

- **Cons**
  - “screening level” model (~10X at best)
  - Which version to use?
  - Need to verify inputs and assumptions
Johnson & Ettinger Model

Johnson & Ettinger most common

- One-dimensional vertical transport
- Steady state conditions
- No preferential pathways
- Uniform mixing within building
- Slab on grade or basement construction
- No biodegradation
- Homogeneous vadose zone
- Constant source concentration
BioVapor Model

1-D Analytical Model
Version of Johnson & Ettinger vapor intrusion model modified to include aerobic biodegradation (DeVaull, 2007).

Oxygen Mass Balance
Uses iterative calculation method to account for limited availability of oxygen in vadose zone.

User-Friendly
Simple interface intended to facilitate use by wide range of environmental professionals.

Free Version from API:
Data Review and Background Evaluation

Key Topics

- Data quality review
- Groundwater, soil, soil gas data interpretation
- Indoor air data evaluation
- Background contributions
Typical Decision Process

1. Start with data quality review
   - Check for bias, consistency with CSM, etc.
2. Compare to appropriate screening levels
   - Protective, so if values < SL, likely no issue
3. Re-evaluate if data are > generic SLs
   - Review critical parameters and sanity checks
4. Utilize other lines of evidence
5. Consider option for pre-emptive mitigation
Data Quality Review

- Program design
  - Well justified scope of work based on CSM and DQOs
- Field methods
  - Samples representative and reproducible
- Laboratory methods
  - Analysis precise and accurate, reporting limits < targets
- Quality assurance / quality control
  - Duplicates, replicates, equipment blanks, container certification, outdoor air samples, building survey, etc.
- Assess consistency with CSM after each phase
  - Compare data to expectations
Common Data Quality Issues

- **Positive bias**
  - Equipment blank samples may show VOCs
  - May also find compounds unrelated to the site

- **Negative bias**
  - Adsorptive losses in sample train
  - Leaks (soil gas and sub-slab)
  - Volatilization losses (groundwater, soil)

- **Variability**
  - Spatial, temporal, operator

Exacerbated because target levels are so low
Interpreting GW Data

- Compare to look-up tables (conservative)
- Use attenuation factor
  - USEPA 2002, local / state guidance
  - Use groundwater or soil gas alpha
- Use J&E model (if allowed)
  - Groundwater spreadsheet if allowed
  - Soil gas spreadsheet if convert to $C_{sg}$

Note: GW Data May Over-Predict Risk
GW Data Exercise

- TCE at 50 µg/L in GW
- GW depth 20’, sandy soil
- H constant = 0.5
- Residential Setting, allowed \( C_{\text{indoor}} = 1 \, \mu g/m^3 \)
- Default GW alpha: 0.0005

Does TCE exceed allowable value?
Is vapor intrusion likely occurring?
Solution - GW Data Exercise

- TCE in soil gas $\sim 50 \, \mu g/L \times 0.5 = 25 \, \mu g/L = 25,000 \, \mu g/m^3$
- TCE in indoor air $\sim 25,000 \, \mu g/m^3 \times 0.0005 = 12.5 \, \mu g/m^3$
- Residential Setting, allowed $C_{\text{indoor}} = 1 \, \mu g/m^3$

Does TCE exceed allowable value?  
YES

Is vapor intrusion likely occurring?
Soil Phase Data

- Soil data generally not acceptable in VI investigations
- Existing soil data – line of evidence
  - Can screen in sites
  - Generally cannot be used alone to screen out sites
- Convert to soil gas concentrations
  - Partitioning equations exist

Note: Soil data often under predicts risk

VI Guideline p. D-6
Interpreting Exterior Soil Gas Data

- Compare to look-up tables (conservative)
- Use attenuation factor
  - USEPA 2002, local or State guidance
- Use J&E model (if allowed)
  - Soil gas screen and advanced spreadsheets

Note: May or may not rule out individual buildings
Interpreting Sub-Slab SG Data

- Look-up tables
- Use attenuation factor
  - From local / state guidance or EPA (0.10)
  - Consider radon to determine slab-specific alpha
- Potential for indoor air to impact sub-slab?
  - Buildings breathe both ways, so it is common to see chemicals from indoor sources in sub-slab samples
Interpreting Indoor Air Data

- Interpretation complicated by ambient background and indoor sources
- Are measured values > allowed?
- Is outdoor air > indoor air?
- If indoor > outdoor, how to determine if VI?
  - Compare to sub-slab concentrations
  - Use constituent ratios
  - Pressure measurements
Comparison to Outdoor Air Data

- Point sources vs. widespread air quality
  - Local dry cleaner
  - Nearby freeway
  - Large urban or industrial area
- Spatial and temporal variability
  - Effect of wind speed and direction, transient sources
- How many samples are needed?
  - Generally at least one for each day of indoor air sampling
Indoor Sources

- Specific sources of indoor air contamination
  - Consumer activities
  - Household products
  - Building materials and furnishings
  - Ambient (outdoor) air
What’s in your house?
What’s in your house?
Indoor Sources

Searchable Household Products Database
http://householdproducts.nlm.nih.gov/

- Chemical ingredients in specific brands
- Which products contain specific chemical ingredients
- Who manufactures a specific brand
- Health effects
Forensics: Constituent Ratios

- Comparing the ratio of two or more compounds in one media with another media (i.e., GW to SG, SG to IA)
- Constituent ratios can provide evidence for and against vapor intrusion
- Attenuation factors can be assessed by comparing values for various compounds (background contributions will tend to increase the alpha value)
Constituent Ratio Example

Compare sub-slab soil gas and indoor air TCE and DCE attributable to vapor intrusion

**TCE = 10 µg/m³**

- **DCE = 20 µg/m³**
- **PCE = 25 µg/m³**

\[ \alpha = 0.01 \]

**TCE = 0.5 x DCE**

**PCE = 2.5 x TCE**

**TCE = 1000 µg/m³**

- **DCE = 2000 µg/m³**
- **PCE = 2.5 µg/m³**

\[ \alpha = 10 \]

**TCE = 0.5 x DCE**

**PCE << TCE**

PCE likely from indoor background source
Constituent Ratio Example #2

Constituent ratio for indoor air does NOT match the ratio for sub-slab soil gas.

\[ \frac{\text{TCE}}{\text{DCE}} = 4 \]

Most TCE in indoor air likely from a background source, but the rest (~10 μg/m³) may still be unacceptable.
Indoor Air Data

Concentration (µg/m³)

Days after system installation

-100 0 100 200 300 400 500

100
10
1
0.1
0.01
0.001

1,1 DCE
DCM
1,1 DCA
1,1,1 TCA
1,2 DCA
PCE
TCE
VC

Courtesy: David Folkes, EnviroGroup
Building Pressurization – TCE

TCE concentration dropped when building was pressurized

- Outdoor Air
- Modeled Indoor Air (Soil Gas x alpha)
- Measured Indoor Air (ambient conditions)
- Measured Indoor Air with building pressurized by ~10 Pa

Berry-Spark et. al., 2005
Building Pressurization – Benzene

Benzene concentration was the same as outdoor air (no VI!!)

Berry-Spark et al., 2005
Consideration of Variability

- Indoor air samples of 24-hours can show up to an order of magnitude temporal variability.

- Deeper soil gas samples tend to have less temporal variability, but tend to overestimate risks for degradable compounds.

- Season climate changes (hot/cold, wet/dry) are minimal in some areas, significant in others.
Summary

- Review data carefully
  - Completeness via comparison to CSM
- Compare to screening levels
- Assess background interferences
  - Ambient and typical indoor data comparison
  - Constituent ratios
  - Attenuation factors
- Assess multiple lines of evidence (MLE)
Mitigation

Key Topics

• Site remediation
• Institutional controls
• Building controls
  • Barriers
  • Venting
  • Pressurization
  • Treatment
Site Remediation

Advantages
- Permanent
- Need to do anyway
- May be lowest cost
- May address other exposure pathways

Disadvantages
- May take too long
- May be too expensive
- Building may be in the way
Site Remediation Example

- Gasoline NAPL plume below school
  - SVE cleanup in source area
  - VI concern in building
Site Remediation Example

- Used existing SVE blower
- Existing foundation drains
Institutional Controls

Legal mechanisms

- Deed notice
- Deed restriction
- Covenant
- Zoning requirement
- Use control area
- One-call notification
- Site management plan
Institutional Controls

Advantages
- Lower cost
- Quick to implement
- Allows time for site remediation

Disadvantages
- Limits site use
- Property value
- Hard to enforce over long periods of time
Building Controls

- Barriers
- Venting
  - Passive
  - Active
- Pressurization
- Treatment
Barriers – Existing Buildings

- Seal cracks and penetrations
- Crawl space liners (e.g. LDPE)

VI Guideline p. 44
Barriers – New Buildings

- Liner below slab
  - Spray-on rubberized asphalt membrane
  - Geomembrane (e.g., HDPE)
Spray-On Barriers

GeoSeal

Courtesy of Land Sciences Technologies

Liquid Boot

Courtesy of CETCO Liquid Boot Company

No product endorsements intended by this presentation

VI Guideline p. 47
Spray-On Barrier & Vent

Courtesy of Land Sciences Technologies

No product endorsements intended by this presentation
Spray-On Barrier & Vent

LIQUID BOOT® GeoVent System

Courtesy of CETCO Liquid Boot Company

No product endorsements intended by this presentation
Aerated Floor System

- Forms create continuous cavity below slab
- Passive or mechanical venting

* Provided courtesy of Pontarolo Engineering, Inc.
No product endorsement intended by this presentation
Passive Venting Mechanisms

- **Passive** venting layers rely on diffusion and natural pressure gradients
  - Thermal-induced pressure gradient
  - Wind-induced pressure gradient
  - Augment with wind turbine
  - Ventilation is primary mechanism

*VI Guideline p. 48*
Active Venting (Sub-slub Depressurization)

- **Active** venting layers rely on fans to create suction (i.e., depressurize venting layer)
SSD in Existing Building

- To Fan
- Riser Pipe
- Seal
- Suction Pit

VI Guideline p. 50
SSD Variations

Block Wall Depressurization

Cinder block foundation wall

VI Guideline p. 51
SSD Variations

Foundation drain depressurization

- Air-tight Seal
- Sump
- Foundation drain
Building Pressurization

- Positive building pressures
  - Requires increase intake air flow
  - Creates downward pressure gradient through slab
  - Increases energy costs

Diagram:
- HVAC
- Diffusion

VI Guideline p. 54
Indoor Air Treatment

- Typical residential unit
  - Size of shop vac
  - 22 lbs of carbon
  - Effective up to 1500 ft²
  - 3 speed 400-CFM fan – runs whisper quiet
  - Electricity demand = 60 watt light bulb

Source: www.allerair.com
Mitigation Summary

- Site remediation
- Institutional controls
- Building controls
  - Sub-slab depressurization
    most common
Take Home Messages

- Vapor intrusion is a complex pathway
  - Source, pathway, receptor
- MLE approach is critical
  - Chemistry, soil properties, degradation, other
- Background sources complicate data interpretation
- One size doesn’t fit all