The Air We Breathe: What You Need to Know About Vapor Intrusion

Regional Science Council
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Presentation Outline

- Vapor Intrusion Pathway
- Scope of the Problem
- Assessment, Sampling & Analysis
- Vapor Intrusion Evaluation (and TCE)
- Mitigation
- Challenges & Future Research Needs

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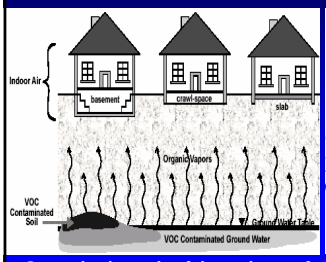
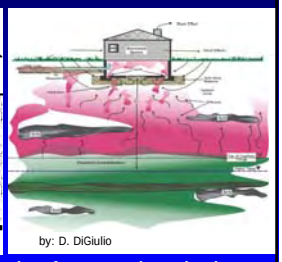
Generic Conceptual Site Models for Vapor Intrusion (VI)





by: D. DiGiulio

General schematic of the pathway of subsurface vapor intrusion into indoor air

http://www.epa.gov/correctiveaction/eis/vapor.htm

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Vapor Intrusion (VI)

- **Chemicals: Volatile compounds (e.g., TCE, PCE, benzene, carbon tet, mercury)**
- **Matrix: groundwater, soil, soil gas**
- **Vadose (unsaturated) or saturated zone**
- **VI caused by the pressure differential between indoor and outdoor air (lower pressure in indoor air)**
- **Physics of VI pathway are similar to radon vapor intrusion**

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Vapor Intrusion – Why It Matters

Vapor Intrusion is Real (sometimes visible)

Hartford, Illinois (gasoline vapors)

Not a perimeter crack (not even on the floor)

- **Explosive risk (rare)**
- **Acute health hazard (rare)**
- **Chronic health hazard**

"Indoor air pollution among the top five environmental risks to public health

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Scope of the Problem – (TCE)

- **374,000-500,000 contaminated sites nationwide**
  - » USEPA, 2002; NRC, 1997
  - **50% of high priority sites have TCE**
  - **50% of those TCE sites have potential VI concern**
  - **25% of high priority sites - VI of TCE**
  - » USEPA, 2003; NRC, 2006
- **1,428 NPL sites (TCE in at least 861 sites)**

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How many (water-table) VOC plumes w/ Vapor Risks ?

15-40 % of sites?

Fan, 2000

Defina, 2000

EPA Region 9 Began Taking a Second Look at TCE and PCE Sites

- In 2002-2003, EPA Region 9 Superfund and RCRA Programs screened over 200 TCE and PCE sites based on existing data to determine the priority of further evaluation of the vapor intrusion pathway.
- Region 9 conducted VI investigations at those sites with the highest potential for vapor intrusion.

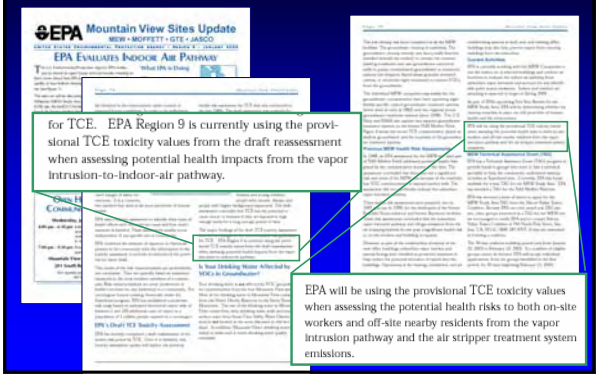
Screening of TCE Sites – Prioritization of VI Pathway Evaluation

- Depth to groundwater – Shallow
- High concentrations of TCE in soil, soil gas, and/or groundwater
- Current land use, occupancy of buildings and future use
- Professional judgement and community concerns

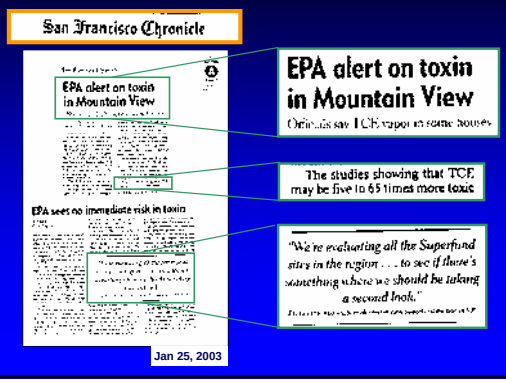
Expedited Review of High Priority Sites

- **High Priority Sites** prompted Site-specific evaluation (e.g., Tier 3 of Draft 2002 EPA VI Guidance)
- **Other Medium and Low Priority Sites** – review information during normal course of process (Remedial, Design, RA, 5-Year Review)
- **Brownfields, UST, Other sites**

EPA Region 9 Mountain View Sites Vapor Intrusion Fact Sheet – Jan 2003



Lots of local press coverage



How Do We Assess Vapor Intrusion Pathway … Measure?…Model? …????

- Indoor/Outdoor Air Sampling
- Concern about potential sources of VOCs in indoor air
  - Consumer products
- Concern about Outdoor air (e.g., Ambient, Air Strippers, SVE)

- Soil gas Sampling
  – outside, sub-slab (inside), shallow, deep, how many?

- Model
  - Controversy about predicting indoor air by relying on a model

- Community concerns about potential health impacts of what people are actually breathing (homes, schools, workplace)

Combination

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Indoor Air Sampling & Analysis

- Work w/ toxicologist to establish action levels
- Obtain permission to sample from property owner and occupant/resident.
- Pre-sampling survey (i.e., construction/age of home, household chemical use, smokers)
- 6-liter summa canisters
- Collect sample over 24 hours at residences (10 hrs, 12 hrs, and 24 hrs, depending on occupancy of building).
- Analyze by TO-15 or TO-15 SIM (Selected Ion Monitoring)
- Test for primary chemicals of concern found in shallow groundwater)

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Types of Air Samples Collected

- **Indoor air** (breathing zone – 3 to 5 ft above ground) – assess potential air exposure
- **Preferential Pathway** - collected in areas/rooms with cracks or penetrations - (i.e., utility or electrical rooms, floor drains, utility vaults, elevator shafts) to assess whether there may be a "completed" pathway from the subsurface into the building
- **Outdoor air (HVAC Intake, outside homes)** – assess what is coming into the building and compare to indoor air samples
- **Outdoor Reference** – compare to indoor air samples
- **Quality Assurance** – duplicates, blanks, EPA co-located (split) samples

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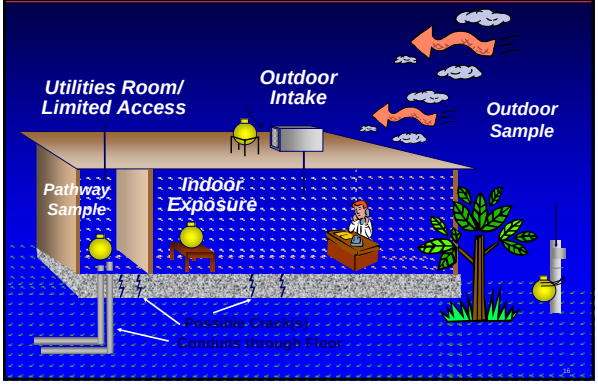
Types of Air Samples



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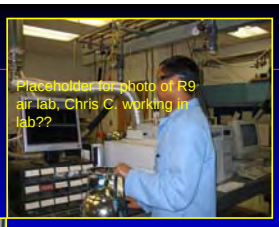
Chris Cagurangan working in the R9 air lab



Summa canisters (duplicate sample) at a residence in Mountain View

Criteria EPA is Using to Evaluate Air Results

➢ **Compare indoor air to outdoor air results**
concurrent indoor/outdoor sampling to help determine outdoor air levels entering the building

❖ Note: It is EPA's policy not to set cleanup levels or take action to reduce levels below background or outdoor ambient levels.

➢ **Compare indoor air results to immediate and short-term health-based screening levels**
{ATSDR Minimal Risk Levels}

➢ **Compare indoor air results to long-term health-based screening levels for residents / indoor workers**
{Using EPA Region 9 PRGs - draft provisional health protective risk range for TCE and Cal EPA's health-based screening level}

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What is TCE?

Trichloroethene (TCE) is a solvent that has been widely used by industry as a cleaning and degreasing agent. TCE is a volatile organic chemical, which means it evaporates readily in air.

What are the Challenges in assessing TCE?

- **TCE is inherently complex toxicologically, with multiple metabolites and multiple potential modes of action.**
- **There is a large database of information on TCE, but there are significant gaps in knowledge.**
- **There are diverse perspectives on a number of science policy issues.**

TCE Metabolism is Complex

- **Rapid absorption via inhalation and ingestion**
- **Readily distributes to blood-rich organs, with sequestration in fat**
- **TCE is metabolized by two competing pathways**
  - **Oxidative (P450) pathway**
    - **Metabolites TCA, DCA, CH**
  - **Glutathione-S-transferase (GST) pathway**
    - **Metabolites DCVG, DCVC**
- **Urinary metabolites are used as biomarkers of exposure**

Major Findings of 2001 Draft TCE Toxicity Assessment

- TCE is likely to cause cancer in humans
  - Exposure to high levels of TCE increase the risk of kidney, liver, hemato-poietic, cervical, and prostate cancers
- TCE can also cause a variety of non-cancer effects if people are exposed to high levels
  - Affects nervous and immune systems, liver and kidney, endocrine and developing fetus

TCE Assessment Focuses on Susceptible Populations

- Those who may be more sensitive to TCE's harmful effects:
  - Children, infants and the developing fetus
  - People with chronic illness (diabetes, liver disease)
  - People using medications (e.g. acetaminophen) or alcohol
  - People with background exposures to solvents and disinfection byproducts

Status of TCE Re-assessment

- **2001 Draft TCE Health Risk Assessment – public review.**
- **2002 EPA Science Advisory Board review.**
- **2004 EPA and other federal agencies initiate scientific consultation with the National Research Council (NRC) to obtain the best available science on key scientific issues related to TCE.**
- **2005 Public meetings held to gain additional insights on TCE.**
- **July 2006 Advice from NRC expert panel on TCE science issues.**
- **2008 and beyond? New revised draft TCE assessment for peer review and public comment. Final assessment and IRIS.**

TCE Re-assessment Updates

For more information and TCE reassessment updates

- **Go to http://www.epa.gov/ncea/**
  Click on the "TCE link under "Risk Assessments
  http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=119268
- **The NRC report – Assessing the Human Health Risks of TCE: Key Scientific Issues can be downloaded for free**

http//www.nap.edu/catalog/11707.html

(click on little button "Sign in to download free PDFs").

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What Region 9 is Doing in the Interim While There Is No Final TCE Value…

- In the interim, EPA Region 9 continues to use both the EPA health protective risk range for long-term exposure and the Cal/EPA health-based screening level.
- Selecting TCE action or mitigation levels where these risk ranges overlap helps to ensure continued protectiveness at each site even if EPA's draft TCE Risk Assessment should change upon finalization.
- Region 9 will continue using the best available science to make site-specific risk management decisions.
- When the TCE reassessment is finalized, Region 9 will incorporate the information into our decision-making process and continue to ensure that existing remedies are protective.

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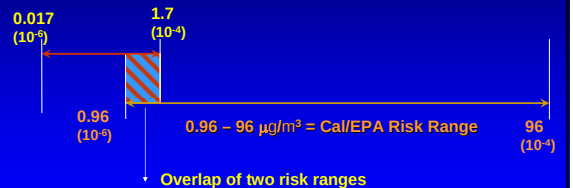
EPA Region 9's Use of Both Provisional TCE Risk Range and California EPA Health-Based Screening Level

RESIDENTIAL

0.017 – 1.7 µg/m³ = EPA Region 9 Provisional Risk Range



Overlap of two risk ranges

Set Action or Mitigation Level

Not to Scale

What We Found

- **Completed vapor intrusion pathway into several buildings and residences**
- **Preferential Pathway samples useful in identifying completed VI pathway (utility/piping conduits, cracks in slab, floor drains).**
- **Subsurface structures (wet basements, utility vaults, elevator shafts)**
- **Varying ventilation conditions in commercial buildings and ventilation makes a difference**

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Interim Mitigation Measures – Easy Fixes

- **Mitigation measures implemented to reduce levels of TCE and other VOCs (sealing potential conduits, modifying ventilation systems, installing air purifiers, sub-slab ventilation systems)**
- **Confirmation air samples collected to make sure mitigation measures are effective.**

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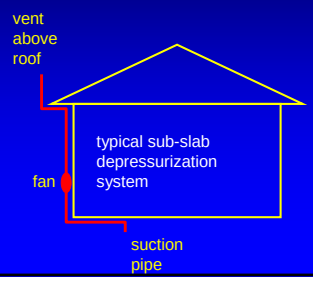
Mitigation of Vapor Intrusion

- **Sub-slab depressurization system**
- **Modifications to HVAC system**



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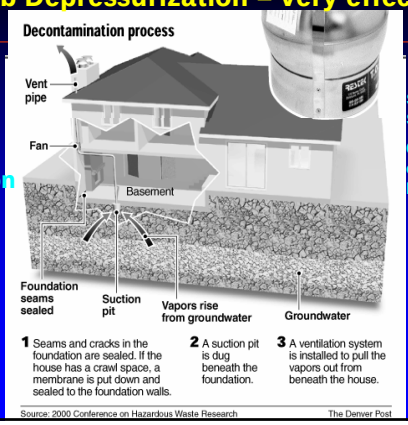
Sub-Slab Depressurization – very effective

99.5% Reduction Possible



$1,500 - $2,500

Cuts off the Pathway

Proposed Mitigation Measures- retrofitting buildings??

Conventional residential-type sub-slab ventilation systems may not be practical at these large existing commercial campuses.

Region 9 generally recommends mitigation measures in design of new building to help prevent vapor intrusion.

Long Term Strategies and Challenges Ahead

- **Selecting Superfund /RCRA remedies to address potential long-term exposure to TCE and other VOCs from the vapor intrusion pathway existing & future land use**
- **Implementing Engineering and Institutional Controls to ensure remedy is effective**
- **Developing Long-Term Air Monitoring Strategies**
- **Reliance on HVAC systems for commercial buildings? (ensure adequate ventilation, positive pressure)**

Long-term Strategies and Challenges Ahead

- Long-term O&M of mitigation systems and long-term effectiveness and monitoring of "sealing of cracks and conduits", vapor barriers and other passive measures
- Future developments - considering of mitigation measures in design of new buildings overlying contaminated shallow groundwater
- Alternative remedial technologies assessing remedial alternatives other than pump and treat for cleaning up the groundwater faster
- Responsibilities and resources

Future Research Needs

- **Improvements in predictive modeling**
- **Toxicity assesments of chlorinated solvents (e.g., PCE)**
- **Optimization and analysis of operating HVAC systems to mitigate vapor intrusion**
- **Future Re-development sites (i.e., Brownfields) – engineering options to minimize the potential for future vapor intrusion**

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