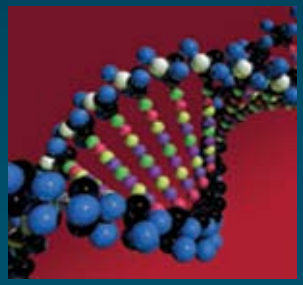
Vapor Intrusion

Regulatory Drivers and Technical Challenges


Air & Waste Management Association – LA Section
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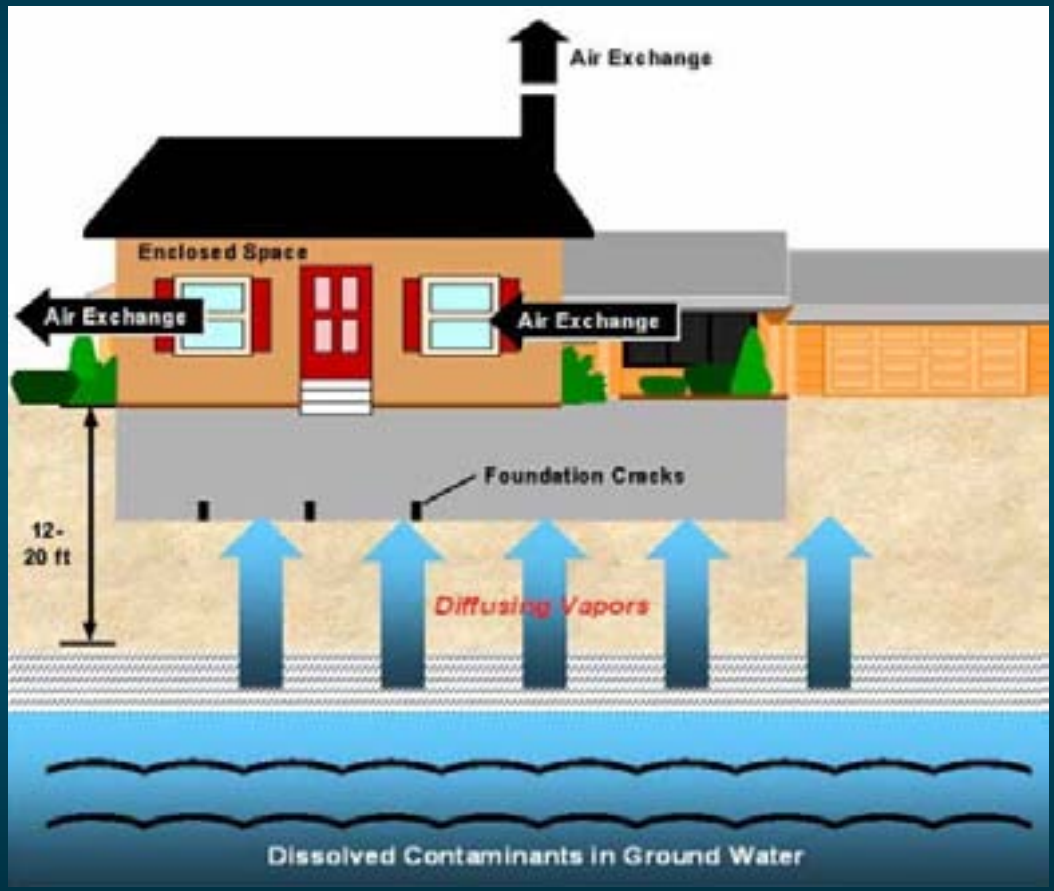
ENVIRON

Presentation Outline

- **What is Vapor Intrusion?**
- **Why is it a hot topic?**
- **Regulatory setting: Federal / State**
- **Indoor air pathway assessment: tips and traps**
  - Modeling
  - Indoor air sampling
    - Watch out for background
  - Soil gas sampling
- **Emerging toxicological issues**
- **Conclusions / Recommendations**

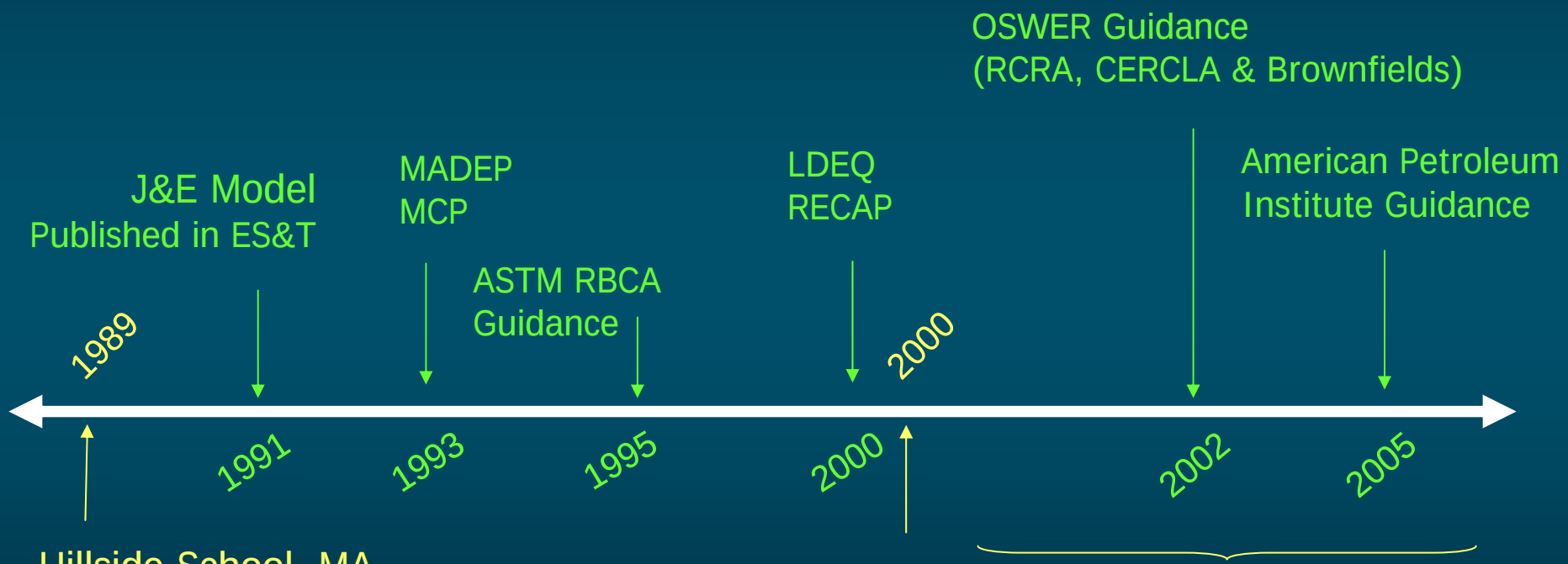
What is Vapor Intrusion?



- Upward diffusion from an underlying source
- Intrusion through cracks
- Dilution in building ventilation
- Source could be soil, soil gas, groundwater, or NAPL

Source: ATK Alliant Techsystems, 2003

Why is it a Hot Topic?

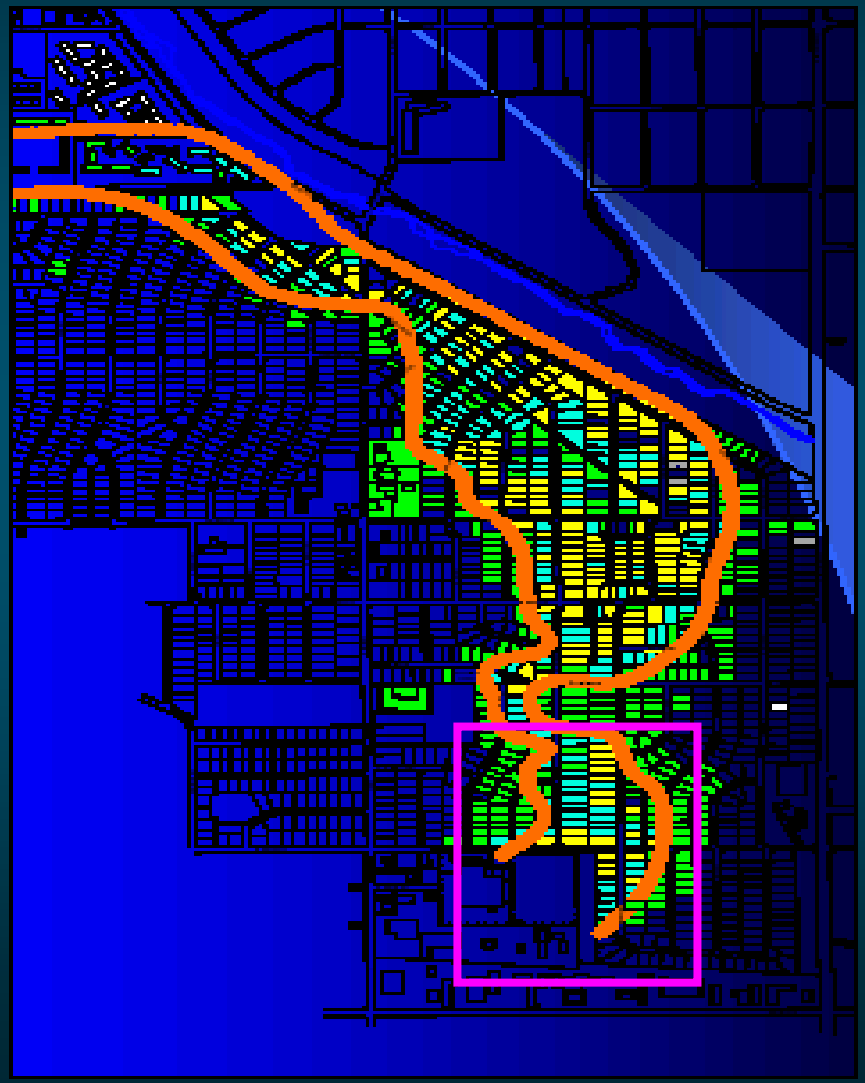


Hillside School, MA
(Microwave Development Lab Site)

Colorado Sites:
CDOT, Redfield,
Alliant
(Denver Post articles)

Multiple Sites Making
News : CA, MA, MI,
NB, NY, NJ, PA, others

Redfield Rifle Site, Colorado



- **Former optics manufacturer**
- **Dispelled common myths**
  - Slab on grade (few basements)
  - Drinking water levels (not ppm)
  - Deep water table (20-30 ft)
- **Solvent plume actually mapped using indoor air sampling**
- **1,1-DCE used as unique tracer**

Outline of 1,1-DCE in GW

Initial Study Area

D. Folkes, EnviroGroup Ltd.

Regulatory Setting

Federal:

Draft RCRA Supplemental EI Guidance October 23, 2001

OSWER Guidance of November 2002

Massachusetts:

GW2/S2 Standards promulgated in 1992

Connecticut/Michigan:

Default numeric criteria since 1996/1998, respectively

Louisiana:

GW and Soil RSES (Enclosed Structures) since 2000

CA, IL, IN, NH, PA, OR, TX, VA, WV, others?

Increase in number of states recently issuing guidance

California:

AB422 (signed 10/15/07) – requires evaluation of VI pathway at all state Superfund and Brownfields sites

2002 OSWER Guidance

- **Intended to be a "unified" guidance for use by RCRA, CERCLA, Brownfields, and States**
- **Assessment through a series of six questions**
  - **Primary Screening (Questions 1-3):**
    - VOCs present? Sufficiently volatile and toxic?
    - Buildings present? (now or in the future)
    - Odors, explosive levels, sickness – immediate response
  - **Secondary Screening (Questions 4-5):**
    - "look-up" tables for soil gas, groundwater
    - "customized" target concentrations
  - **Site-Specific Assessment (Question 6):**
    - Field investigations

RECAP 2003

- **Provides default GW and Soil RS for the "Enclosed Structure" pathway**
  - Cover non-industrial (residential) and industrial receptors
  - RS_{es} Equations based on J&E model
  - Site-specific phys/chem adjustments in MO-2
  - Some model inputs updated in OSWER guidance after RECAP was released for public comment, therefore not incorporated
    - DEQ will accept some modifications (conditions apply)
- **Pathway can be assessed through soil gas and/or indoor air sampling**
- **Occupational standards may be used under MO-3 for industrial sites**

GW Standards: States vs OSWER

Groundwater criteria for a residential vapor intrusion scenario

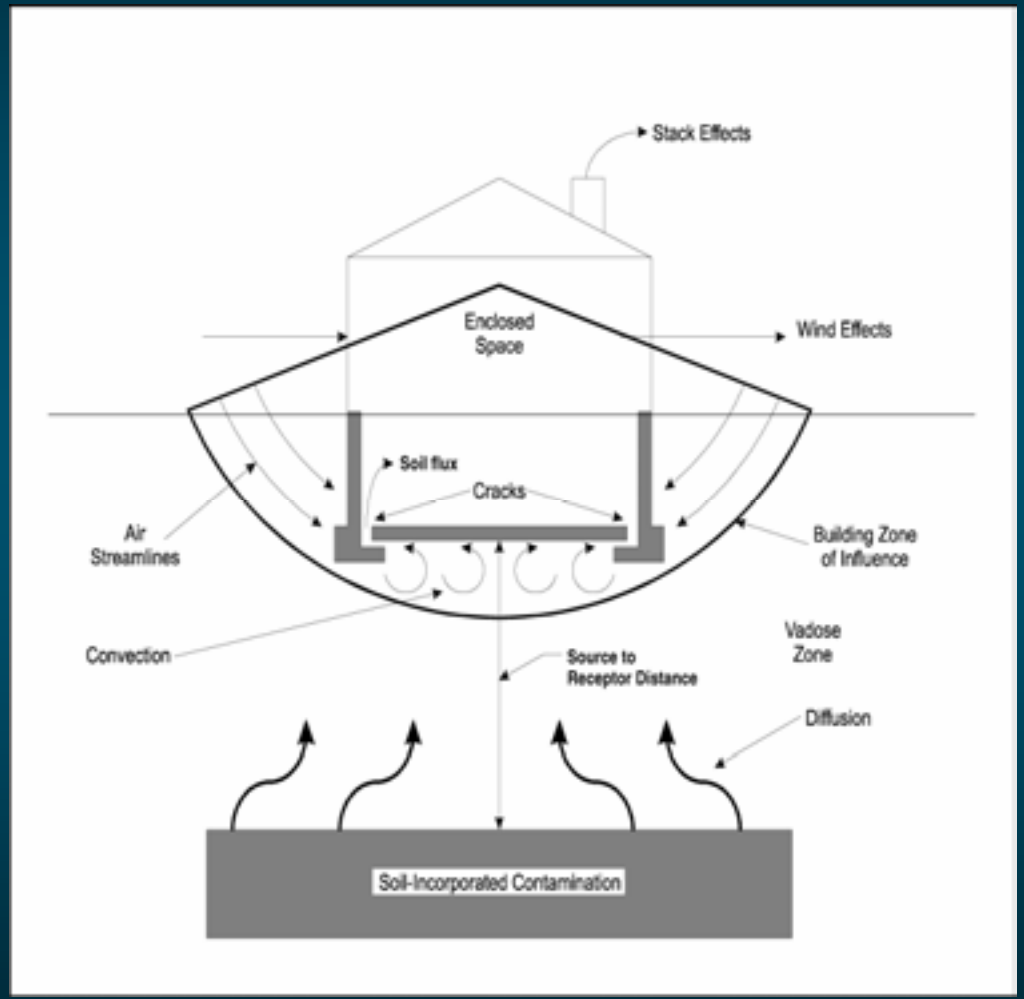
	Benzene	1,1-DCA	TCE
MI	5,600	1,000,000	15,000
OR	180	NA	NA
VA	12	2,260	35
MA	2,000	9,000	300
LA (GW_{esni})	2,900	140,000	10,000
OSWER	140	2,200	5.3

** All concentrations in ug/L

Assessing Vapor Intrusion

- **Screening against default soil and groundwater criteria**
- **Modeling**
- **Indoor air sampling**
  - Background concerns
  - Low target concentrations
- **Soil gas sampling**
  - Still need to estimate how much gets into indoor air
  - Alpha factor: empirical vs. modeled

Mathematical Models



Johnson and Ettinger, 1991

J&E Model:

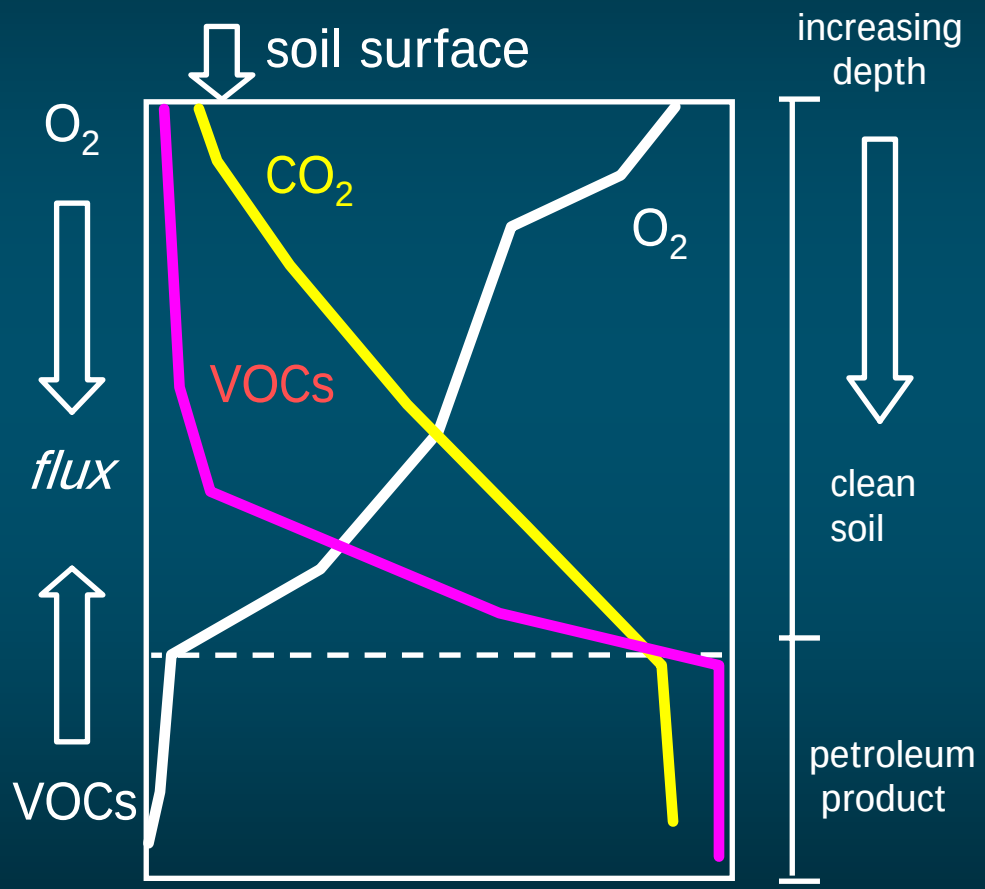
- Steady-state upward diffusion from an underlying source
- Intrusion through a perimeter crack
- Source could be soil, soil gas, groundwater, or NAPL
- Generally conservative but beware of misapplication

Modeling Advancements

Vadose zone biodegradation

Johnson et al. 1999, Abreu and Johnson 2005

- Biodegradation of petroleum hydrocarbons well accepted
  - O_2 typically limiting condition
- Need additional data to evaluate/model
- Discussed in API 2005 Guidance
- Can reduce alpha factor by 10- to 1000-fold

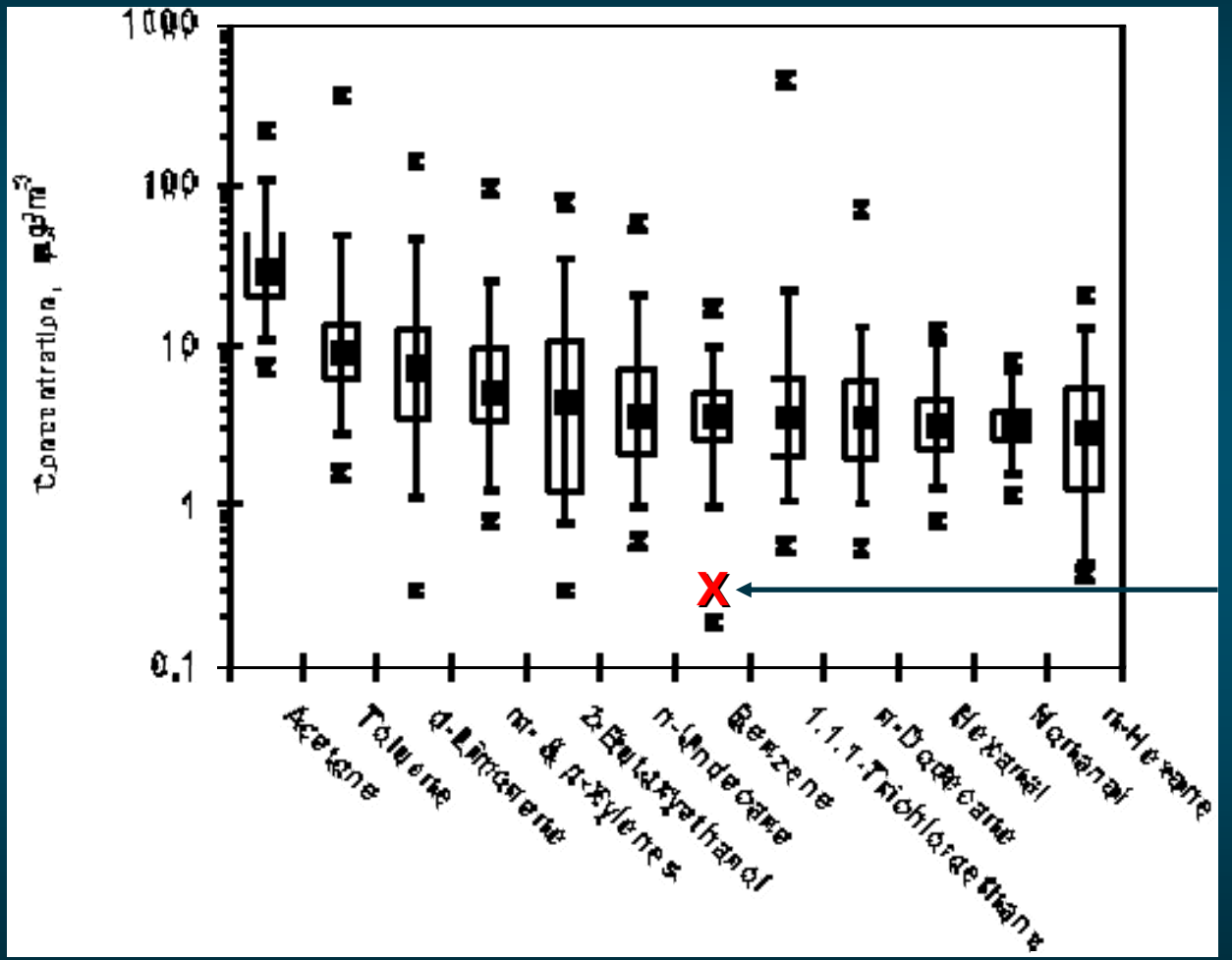


Indoor Air Sampling

Indoor Air Sampling

- **<u>DO NOT</u> sample indoor air as a first step**
- **May ultimately be needed to confirm modeling or soil gas data**
- **Regulatory Agency may initiate its own sampling**
  - QA/QC should be reviewed in detail
  - Collect OAQ data, blanks or lab-replicates
  - Conduct a survey of occupants, internal sources
  - Clearly identify target compounds

VOCs with Highest Indoor Concentrations



Benzene indoor air quality level for 1 in a million risk

From USEPA BASE study Minimum, maximum, 5, 25, 50, 75, 95th percentiles

Girman, J. *Air Toxics Exposure in Indoor Environments,* EPA Workshop on Air Toxics Exposure Assessment, 2002. http://www.epa.gov/osp/regions/airtox.htm

Comparison of Typical Background Concentrations to Risk-Based Levels

Chemical	Range of Bkgrd Concs. (ug/m^3)	Risk-Based Concs. (ug/m^3)	
Benzene	3 - 5	0.31	c
Chloroform	1 - 4	0.11	C**
1,1 Dichloroethane	<0.08 - 0.2	500	nc
1,2 Dichloroethane	0.04 - 0.09	0.094	c
1,1 Dichloroethene	<0.04 - 0.01	200	nc
Ethylbenzene	3 - 5	2.2	c
Methylene Chloride	0.8 - 10	5.2	c
Tetrachloroethene	1 - 5	0.81	c
Toluene	7 - 20	400	nc
1,1,1-Trichloroethane	0.7 - 50	2200	nc
Trichloroethene	0.1 - 5	0.022	c
Vinyl Chloride	0.01 - 0.02	0.28	c
Xylenes	9 - 15	7000	nc

Risk Based Concentrations from EPA 2002 Vapor Intrusion Guidance
Assumed target risk for carcinogens is 1E-6

Background Indoor Air Sources

Source	Benzene	Toluene	Ethylbenzene	Xylene	Styrene	Trimethylbenzene	Naphthalene	Trichloroethene	Trichloroethanes	Perchloroethene	Chlorobenzene	Decane
Latex Paints	X	X				X						
Alkyl Paints										X	X	
Carpets	X	X			X	X						
Glued Carpets	X	X			X	X					X	X
Wood Burning		X		X	X	X	X					
Foam Board											X	
Paint Removers		X										
Spray Products				X								
Adhesives/Tapes		X			X			X				X
Room Deodorants											X	
Tobacco Smoke	X	X	X	X	X							
Gasoline/driving	X	X		X	X	X						
Solvents		X	X									
Dry Cleaning									X	X		

From Herz et al., 2001. The use of indoor air measurements to evaluate intrusion of subsurface VOC vapors into buildings, J. Air & Waste Manage. Assoc. 51:1318-1331.

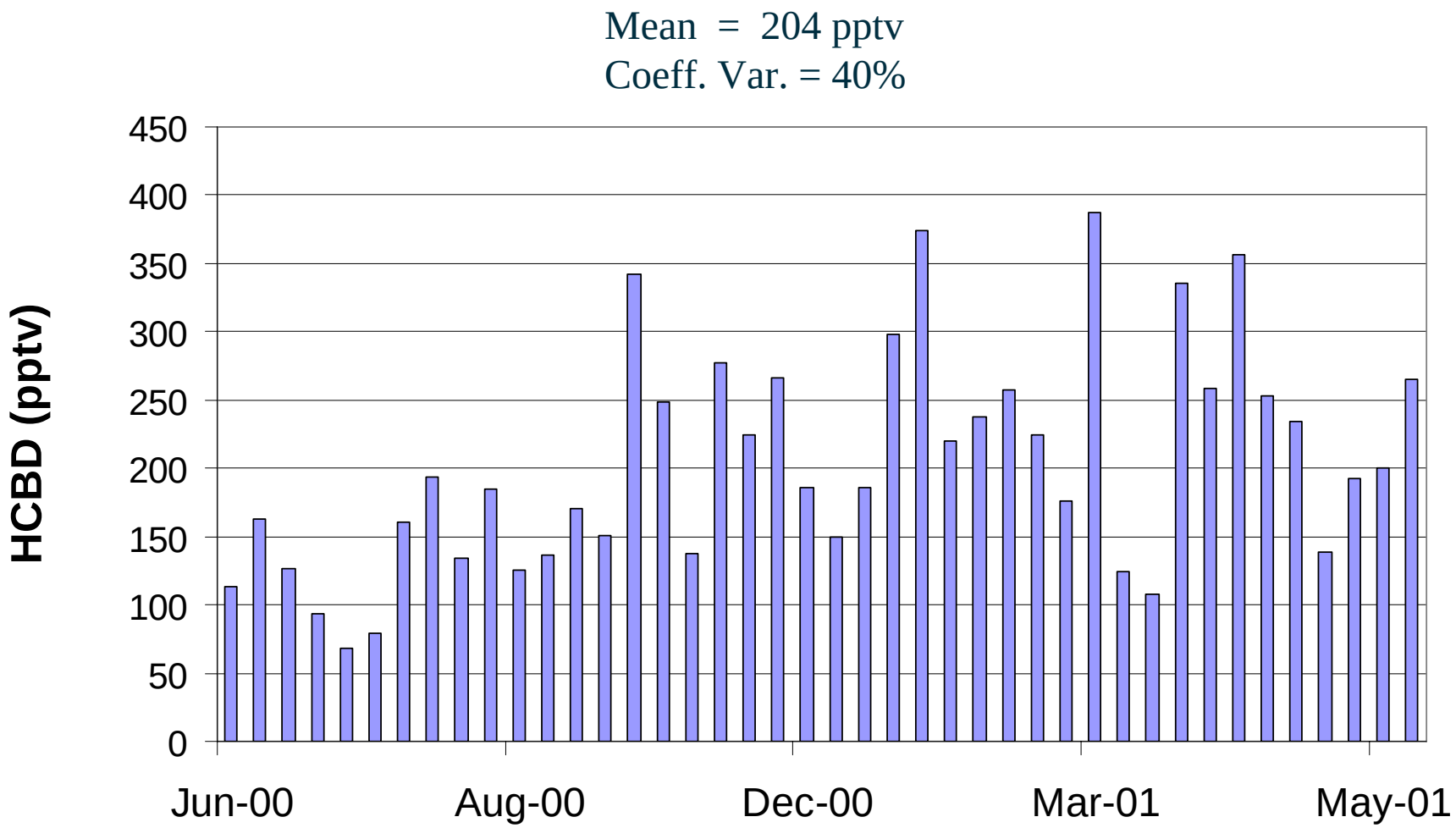
Background Sources!

(Mickunas, 2004)

Indoor Air Sampling - Instructions to Occupants

- **48 hours prior to sampling**
  - No smoking
  - No cleaning
  - No painting
  - No indoor hobbies that use solvents
  - No cosmetics use
  - No gasoline storage or use

Temporal Variability of Indoor Air Quality



How much data is enough?

Residential vs. Occupational

Chemical	C / NC	Residential IAQ Target at 1E-6 Risk or HQ=1 (ppb)	OSHA PEL TWA (ppb)	ACGIH TLV TWA (ppb)
1,1,1-Trichloroethane	NC	400	350,000	350,000
1,1,2-Trichloroethane	C	0.028	10,000	10,000
1,1-Dichloroethane	NC	120	50,000	100,000
1,2-Dichloroethene (cis)	NC	8.8	200,000	200,000
1,2-Dichloroethene (trans)	NC	18	200,000	200,000
Benzene	C	0.098	10,000	500
Carbon Tetrachloride	C	0.026	10,000	5,000
Chloroform	C	0.022	--	10,000
Naphthalene	NC/C	0.57	10,000	10,000
Tetrachloroethene	C	0.12	100,000	25,000
Toluene	NC	110	200,000	50,000
Trichloroethene	C	0.0041	100,000	50,000
Vinyl Chloride	C	0.11	100,000	5,000

- **Occupational standards much more lenient**
- **EPA will defer to OSHA standards for protection of worker exposure**
- **LDEQ will consider OSHA standards in MO-3 with certain conditions**

Alternatives to Indoor Air Sampling

- **Soil Gas Sampling**
  - Still need to determine alpha factor
  - Soil gas × alpha factor

$$\alpha = \frac{C_{Bldg}}{C_{soil\ gas}}$$

- **Three options for alpha**
  - Generic (OSWER Guidance)
  - Tracer (e.g., radon)
  - Model (J&E, 1991; others)

Soil Gas Sampling

Sub-Slab Soil Gas Sampling

Shroud around probe filled with butane from lighter.

Analyze sample for butane to confirm absence

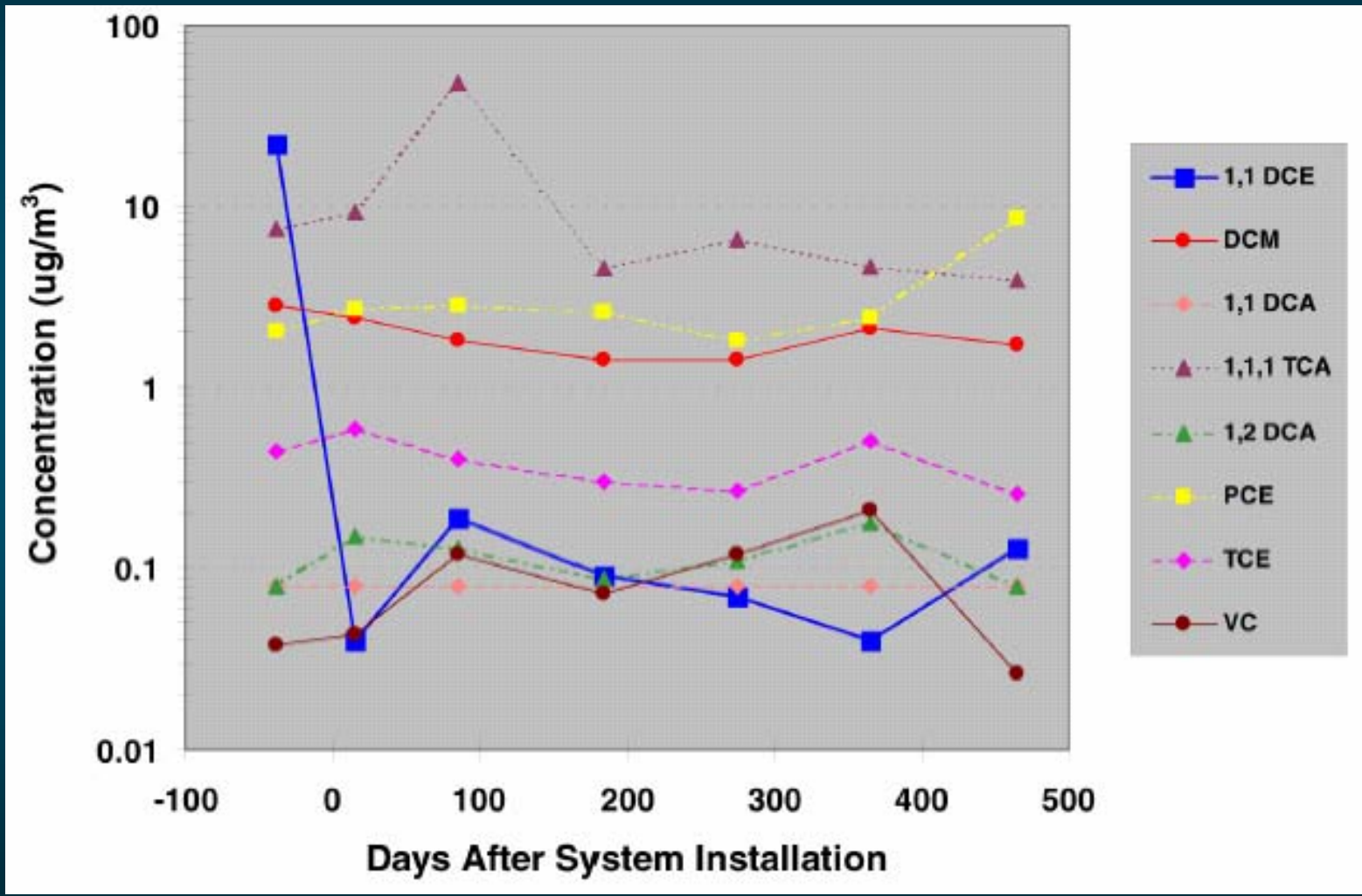
“Emerging” Toxicological Issues

- **TCE**
  - **Cancer potency estimate withdrawn in 1989 – often still used**
  - **EPA reassessment complete in 2002**
    - Several new estimates based on different studies
    - Estimate “selected” by EPA is >60-times more potent (Used in RECAP)
    - Much comment/debate ensued
  - **NAS review in 2006… final value expected in 2008**
  - **8 of 10 EPA Regions use new value, several states**
  - **Will be risk driver at many sites**
- **Naphthalene**
  - **Currently considered a non-carcinogen**
  - **Proposed cancer potency estimate**
  - **IAQ target would decrease by 300-fold at a 1E-6 risk level.**

Remedial Options

- Active Remediation
- Institutional Controls
- Engineering Controls
  - Radon control system
  - HVAC modifications
  - Sealing
  - Filtration
  - Building design

Mitigation vs. Background



CDPH&E, 2000

Conclusions

- **Target concentrations can be very low**
  - Similar to background, lower than DLs in some cases
- **Conservative screening approaches will require site-specific evaluation in some cases**
- **Site investigation methods require careful planning**
- **Assessment can be a challenge**

Recommendations

- Collect sufficient OAQ data (one is not enough!)
  - >90% of indoor air is from outside
- Collect soil gas data
  - identify compounds of potential concern
  - identify ratios of soil gas to IA concentrations (should be similar for most VOCs. If not, suspect background)
- Develop, document and implement rigorous protocols
  - there's more bad data out there than most folks realize
- Assess the costs of proactive exposure controls
  - IAQ monitoring can get very expensive
- Multiple lines of evidence are best
  - IAQ, OAQ, Soil Gas, groundwater data

Questions

Thanks for Attending