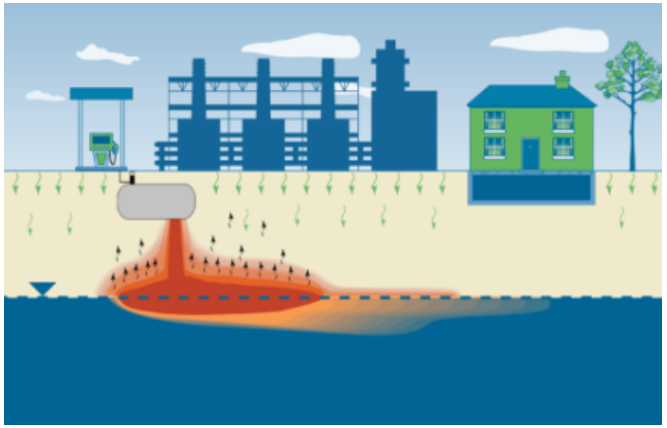
Follow ITRC

Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management



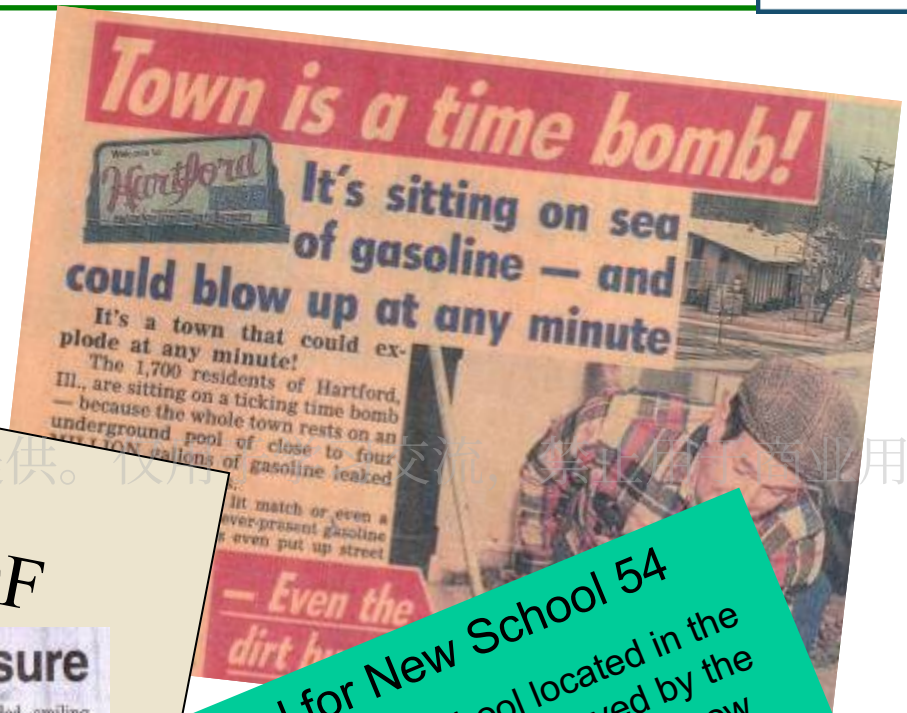
7 June 2018
Beijing, People's Republic of China

Vapor Intrusion - So What?

August 8, 2005

DANGER BENEATH OUR FEET

"IS MY FAMILY SAFE?": A COMMUNITY VIEW OF VAPOR INTRUSION



Town is a time bomb!

It's sitting on sea of gasoline — and could blow up at any minute

It's a town that could explode at any minute!

The 1,700 residents of Hartford, Ill., are sitting on a ticking time bomb — because the whole town rests on an underground pool of close to four [illegible] gallons of gasoline leaked [illegible] it match or even a [illegible] ever-present gasoline [illegible] even put up street

— Even the dirt [illegible]

Corzine signs day care safety measure

By Ashley Randazzo

arandazzo@gsnewsco.com

FRANKLIN TWP. — Joanne McCleery choked back tears from the moment she entered the Delsea Regional High School auditorium until the governor's signature was dry.

She had joined nearly 20 parents – and numerous former students – from Kiddie Kollege day care on Thursday to observe Gov. Jon Corzine as he signed a bill designed to prevent the mercury contamination that shut the day care from happening again in the state.

"I just think of what could have happened if someone didn't find this," McCleery said as she broke down in tears before the ceremony.

MADDEN MAYER MORIARTY

Tristan, McCleery's 4-year-old son, and her 6-year-old daughter, Autumn, were students at Kiddie Kollege for two years.

"I'm thankful for whoever stumbled across this because (my kids) would have continued to be in that day care. We were happy with the place,"

McCleery added, smiling at Tristan in the seat beside her.

Corzine travele[d] Franklin T[wp.] Thurs[day] mea[sure] legis[lation] the K[iddie] mare. [illegible] the le[gislation] Departm[ent] mental Protection Com[missioner] Jackson and Departm[ent] and Senior Services C[ommissioner] Fred Jacobs.

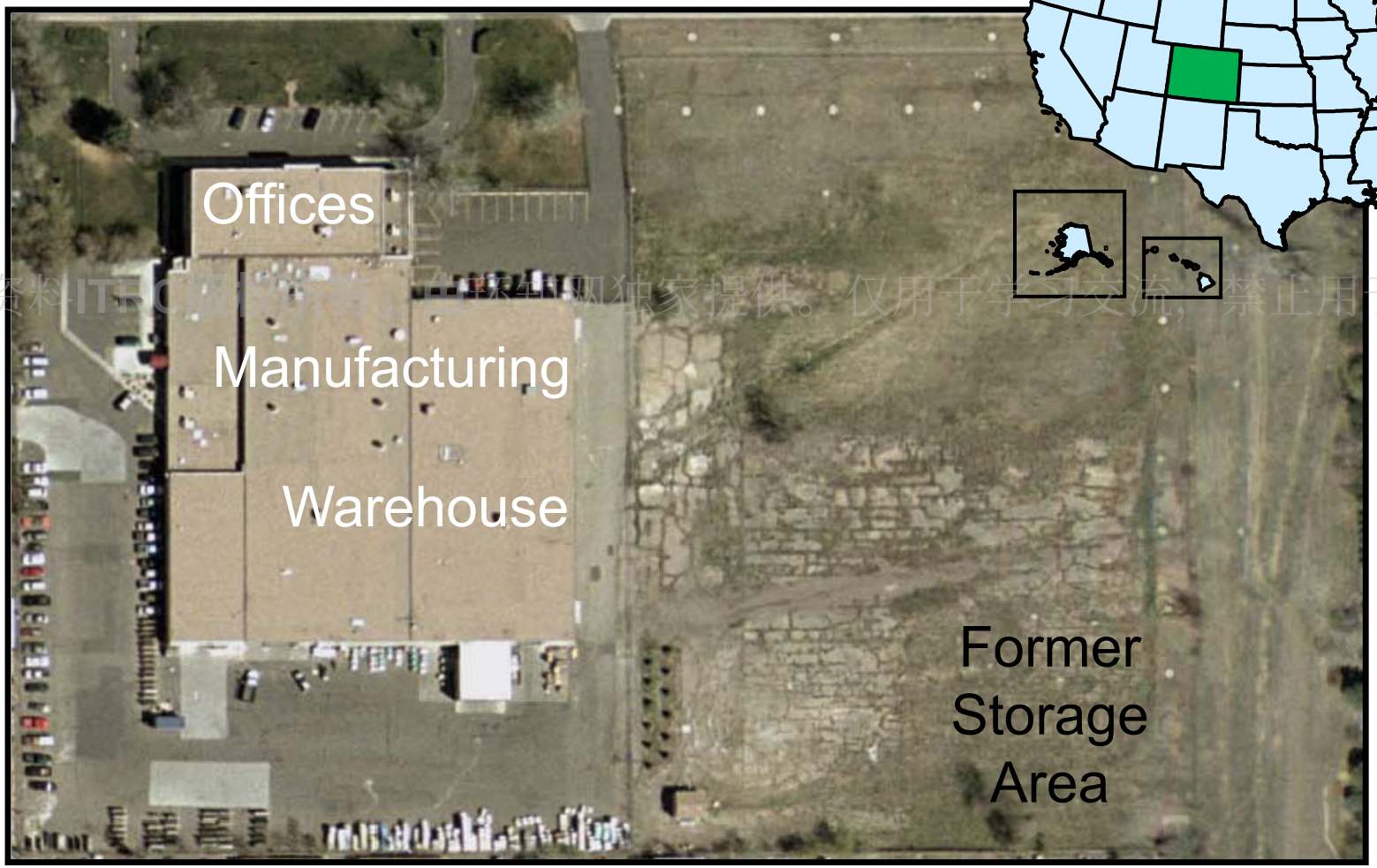
Fourth District Sen. Fr[ank] and Assemblymen David M[arder] Paul Moriarty sponsored the

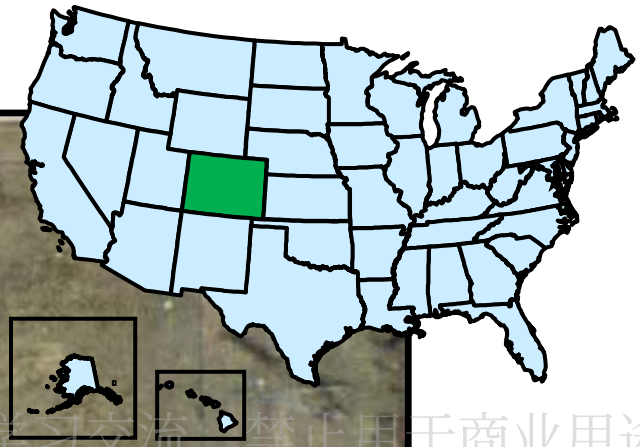
(See MERCURY, Page A-

Vapors End Deal for New School 54

A defunct Rochester charter school located in the former Mapledale Party House, once eyed by the city as a possible site for a public school, is now considered by the city to be too contaminated to consider buying.

Redfield Rifle Scope Site - Denver, CO

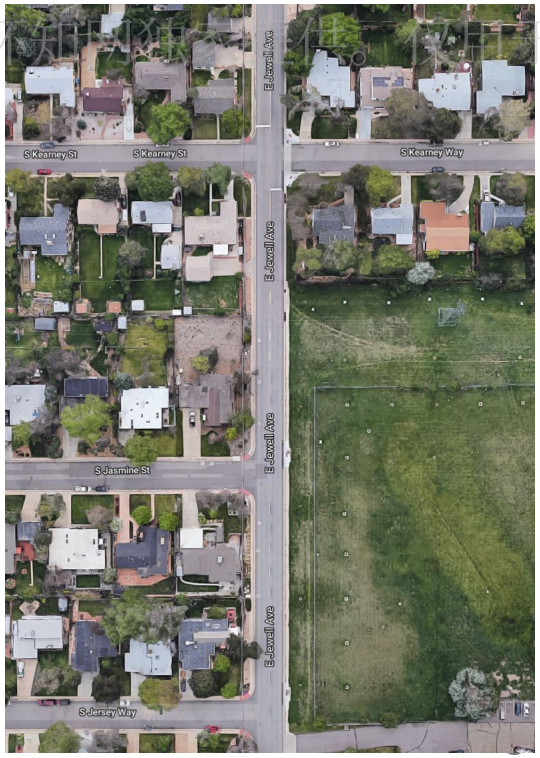


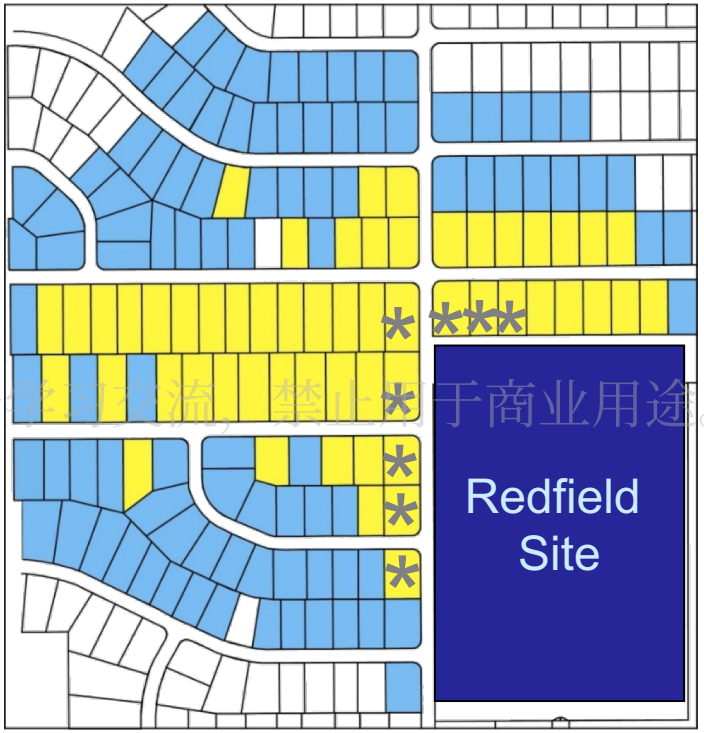


Initial Investigations

Redfield Rifle Scopes Site

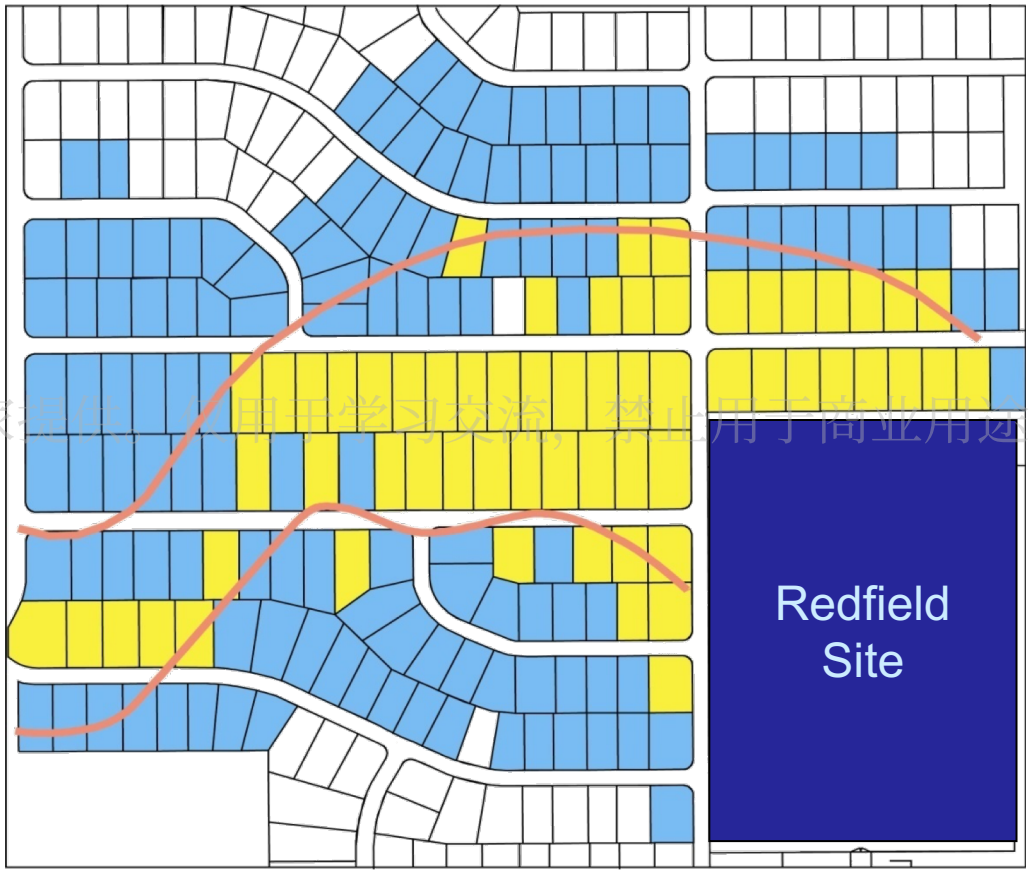
- First major vapor intrusion site in the United States
- 4645 m^2 building on 10 acres (40,500 m^2)
- 1,1-Dichloroethene is contaminant of concern





Further Investigation

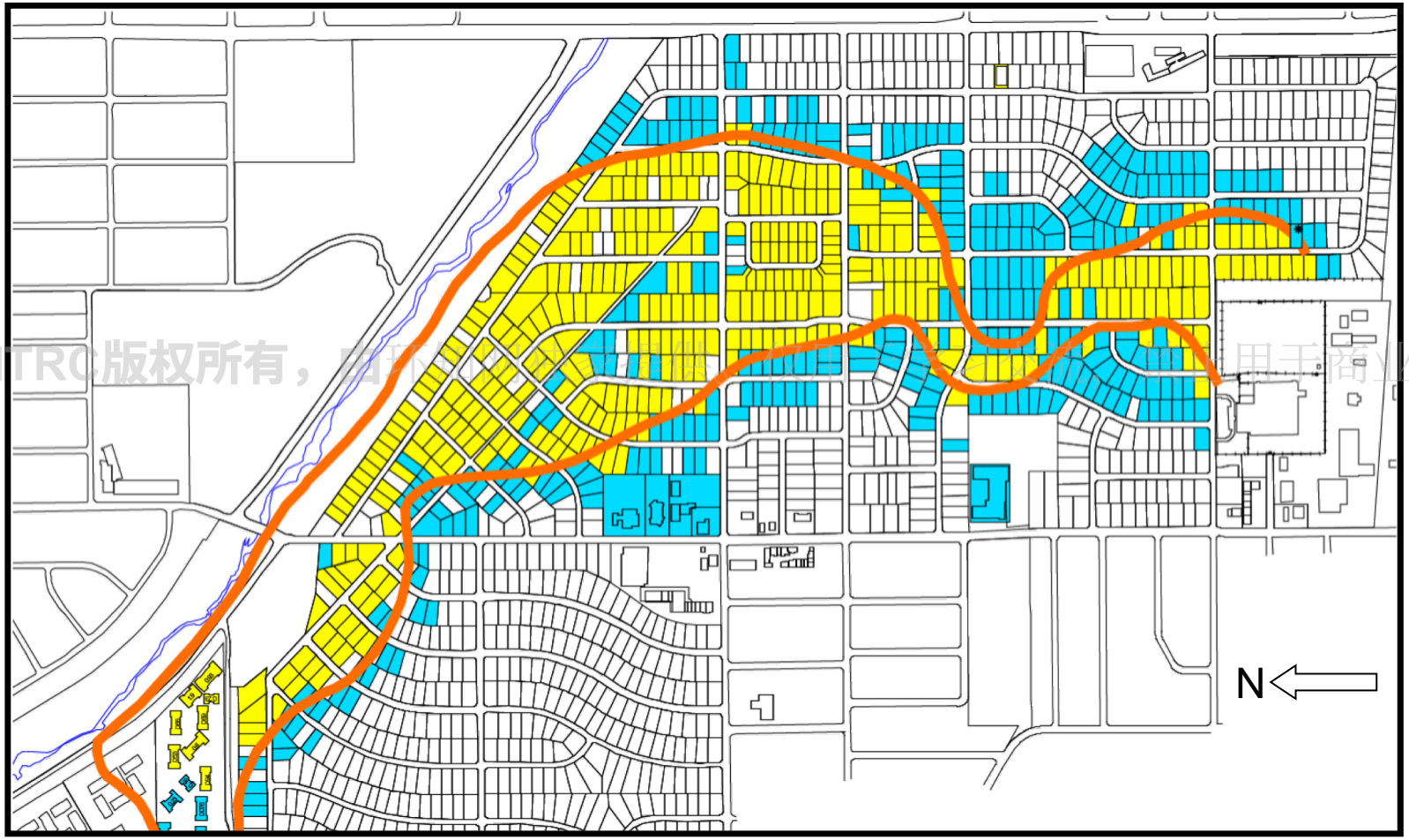
- In Spring of 2000, IA sample results revealed high levels in an area contrary to expected groundwater flow (and uphill)
- Geologic buried channel discovered
- IA results proved very accurate in guiding groundwater investigation



DCE > 7 µg/L

DCE < 0.49 µg/m³
DCE >= 0.49 µg/m³

Ultimate Extent of Vapor Intrusion



What You Should Learn

- Understand the fundamentals of vapor movement and the essential principles of biodegradation
- Develop on-the-job skills to screen-out petroleum sites based on the scientifically-supported ITRC strategy
- Focus the limited resources investigating those petroleum vapor intrusion (PVI) sites that truly represent an unacceptable risk
- Recognize the extensive options for investigating and mitigating PVI sites

PVI Classroom Training – Outline

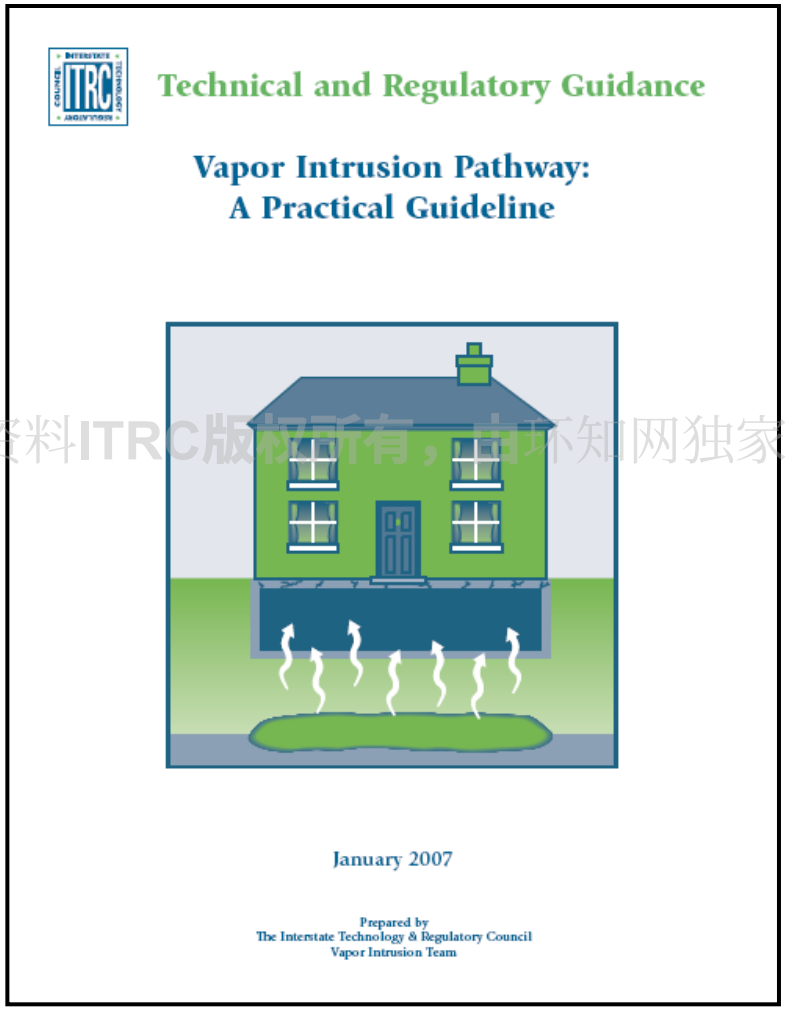
Morning

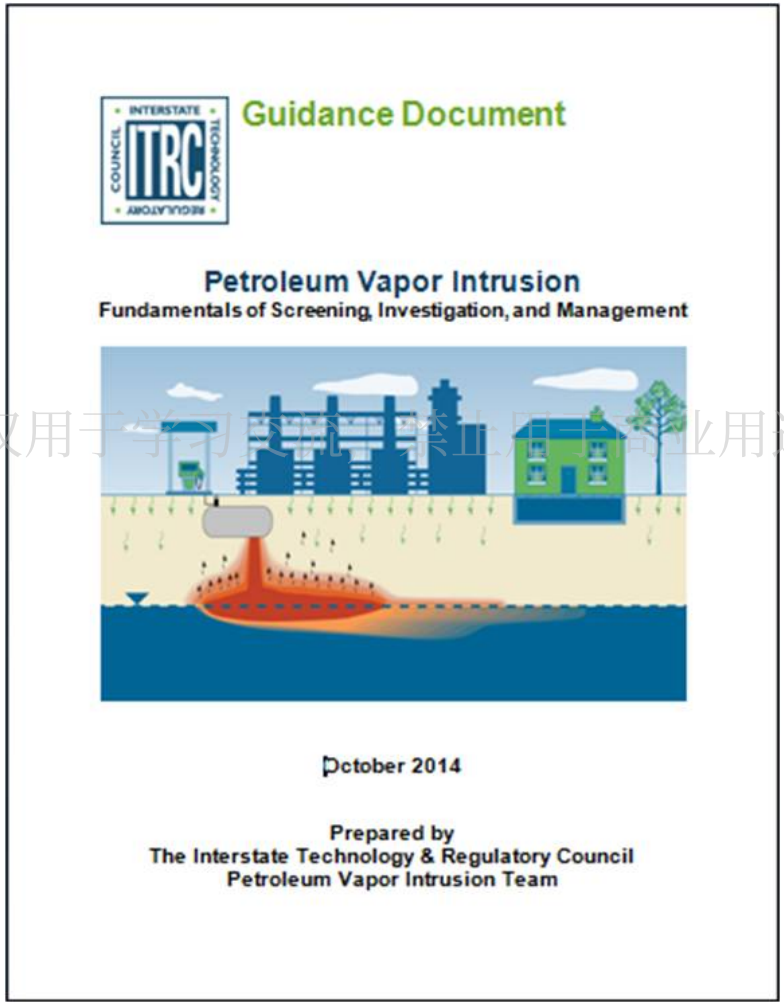
- Welcome
- ITRC Introduction
- General VI Overview
- VI: Chlorinated vs Petroleum Hydrocarbons
- Lunch

Afternoon

- Petroleum VI Screening
- Investigative Approach
- Data Evaluation
- Vapor Control and Site Management
- General Remediation

Basis for the Training – ITRC Guidance





https://www.itrcweb.org/Team/Public?teamID=22

Meet Today's Trainers

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General VI Overview

Key topics

- Defining vapor intrusion (VI)
- Presenting important concepts of VI, including principles of vapor movement
- Giving an historical perspective on VI

Morning

Welcome

↓

ITRC Introduction

↓

General VI Overview

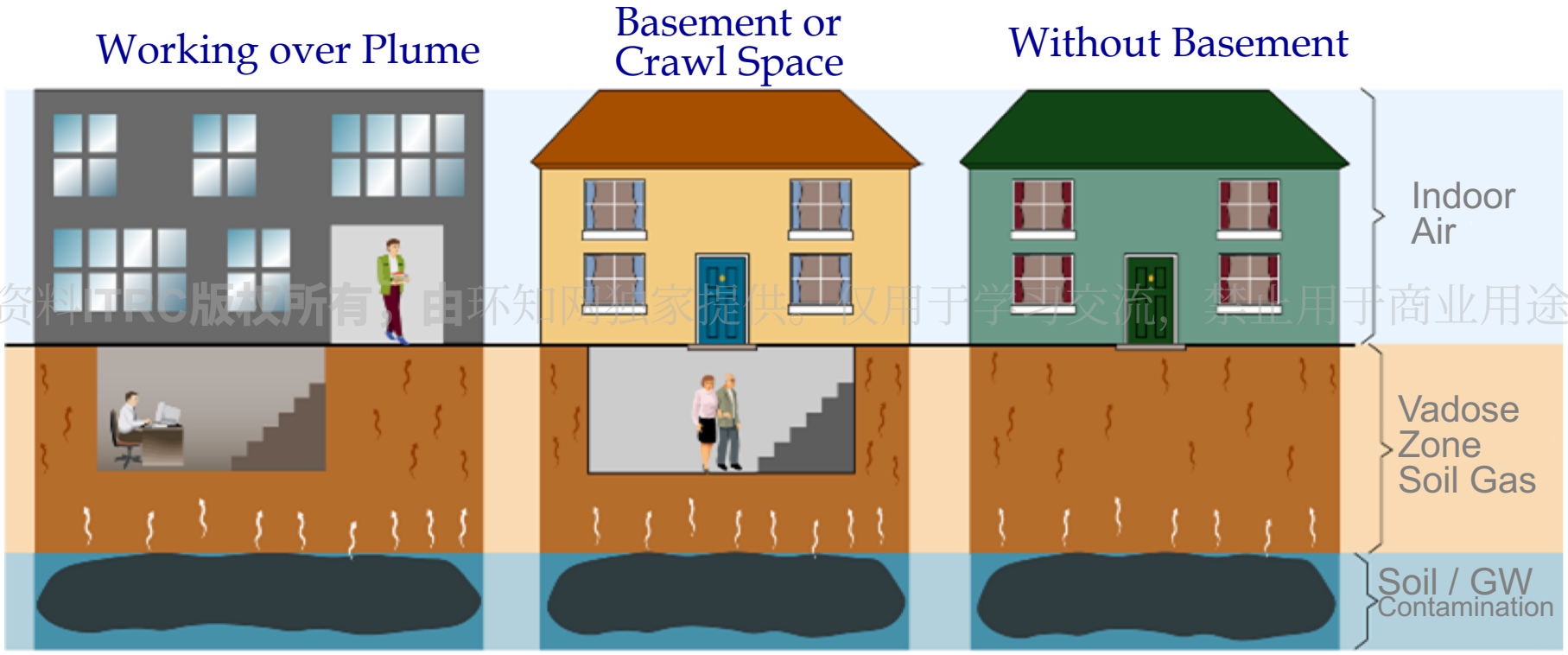
↓

VI: Chlorinated vs Petroleum Hydrocarbons

↓

Lunch

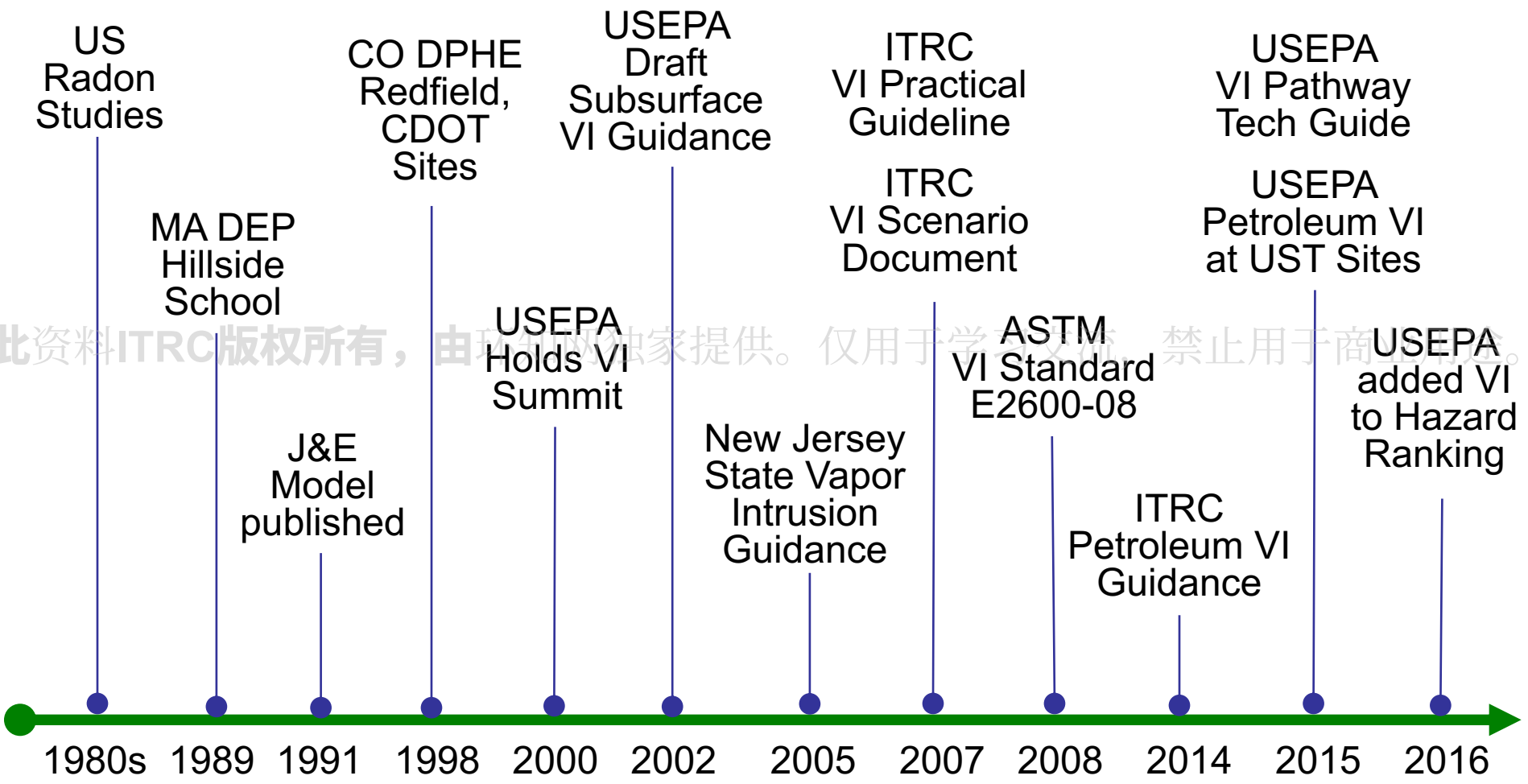
Vapor Intrusion (VI) Pathway



The process by which volatile hydrocarbons partition from contaminant groundwater or other subsurface sources and migrate upward through the vadose zone soils and into overlying buildings

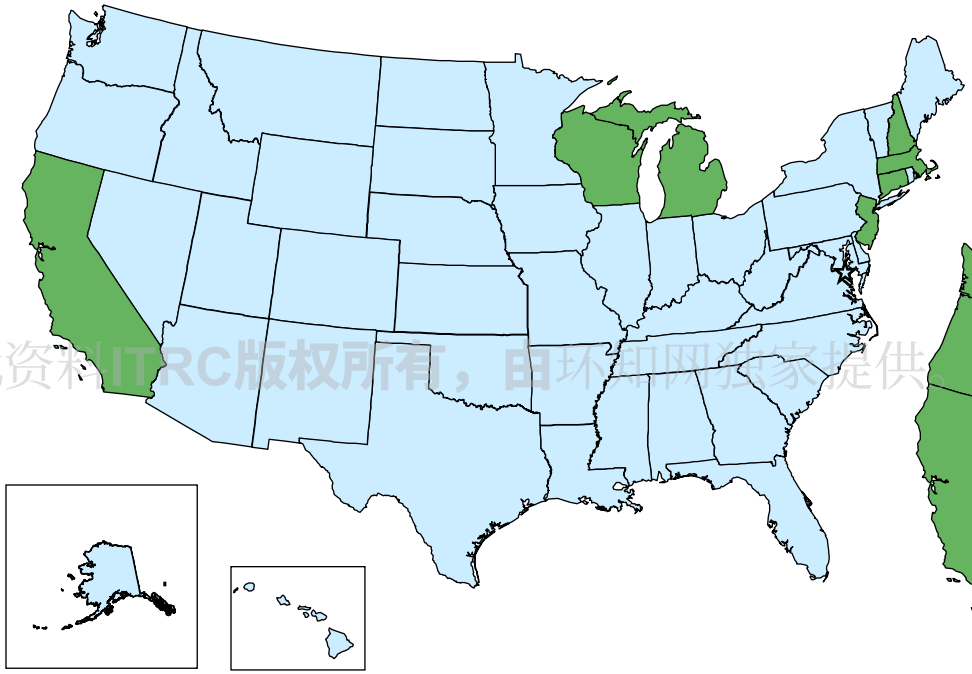
Courtesy: ITRC

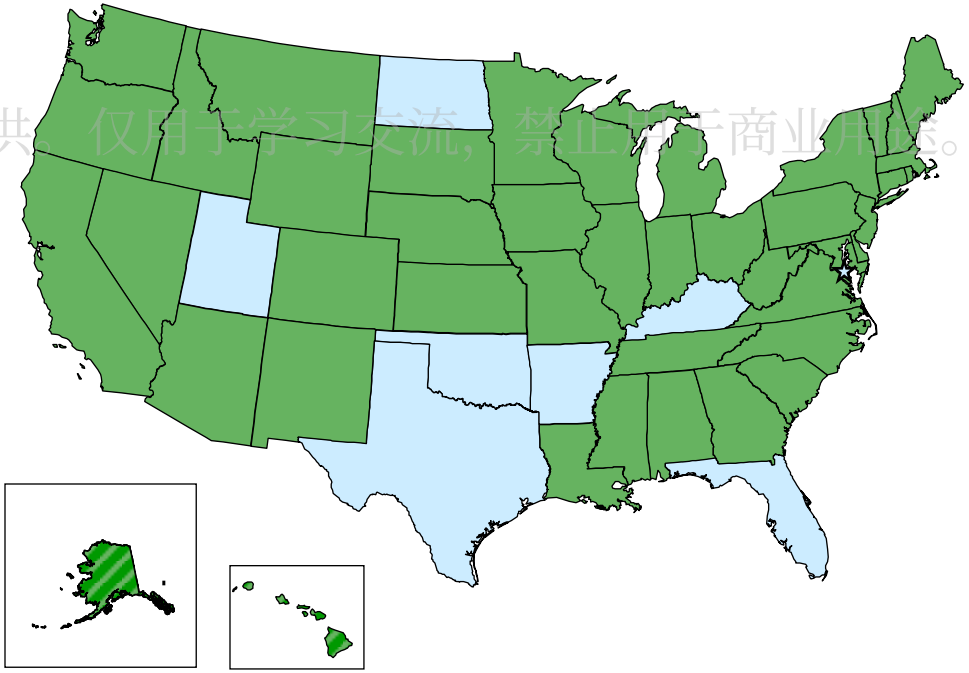
US Historical Perspective



VI Regulatory State Guidance

States with Regulatory VI Guidance in 2004

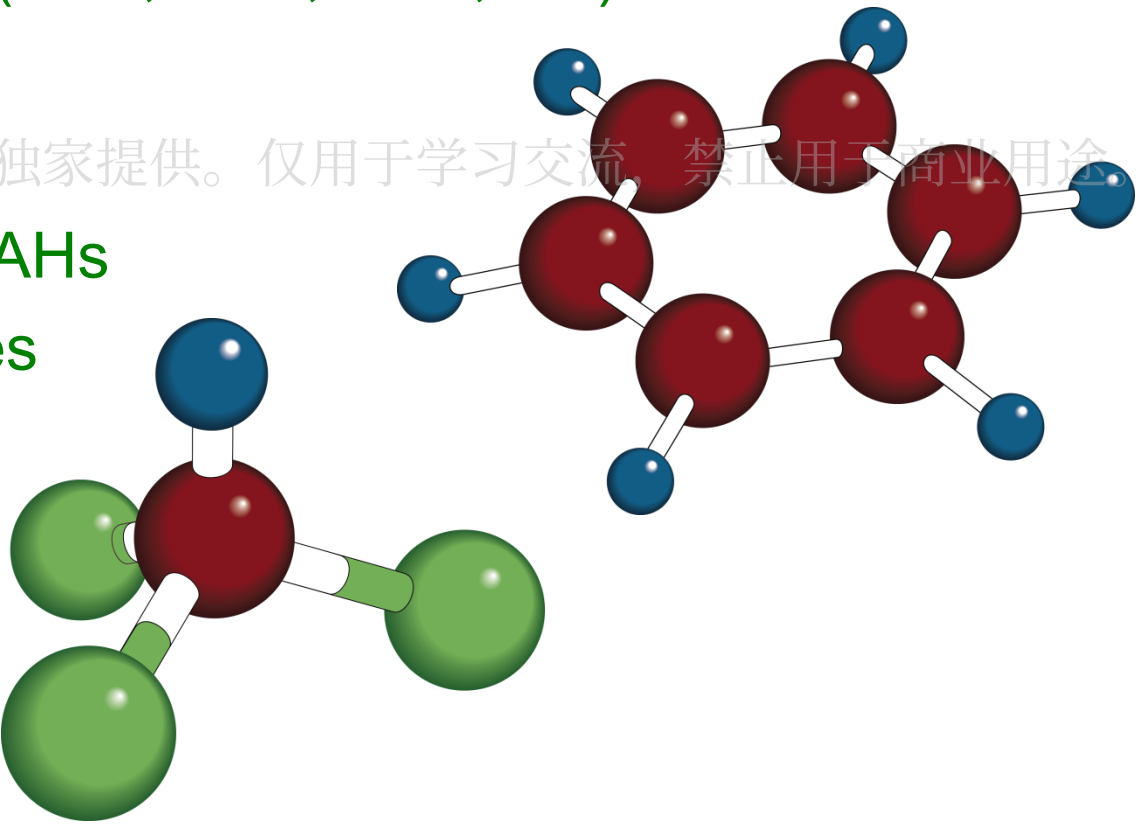




States with Regulatory Guidance in 2018

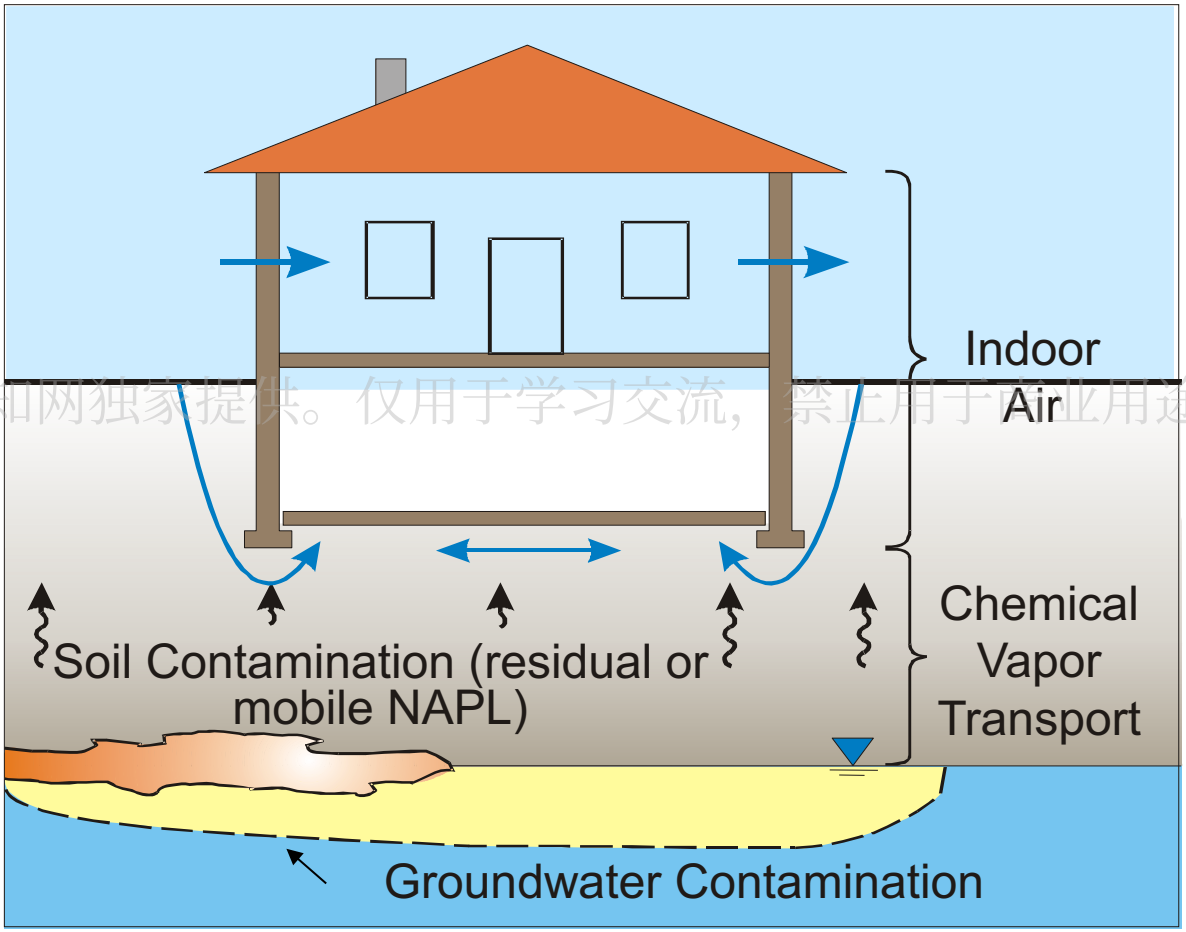
Types of VI Compounds

- VOCs
  - Petroleum Hydrocarbons
  - Chlorinated HCs (TCE, TCA, PCE, VC)
  - Methane
- Semi-VOCs
  - Naphthalene & PAHs
  - PCBs & Pesticides
- Metals
  - Hg



Sources of Vapor Intrusion

- Soil contamination
- NAPL (nonaqueous phase liquid)
- Groundwater plumes
- Vapor cloud

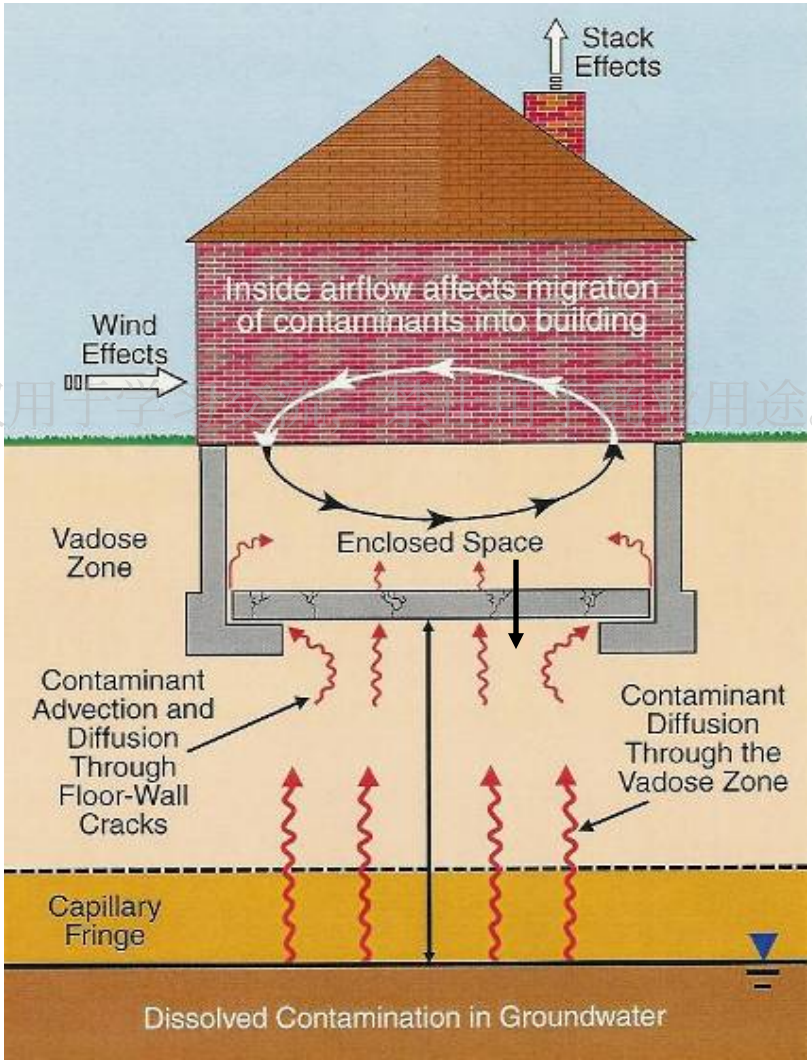


Courtesy: Ian Hers, Golder Associates

Principles of Vapor Movement

- Partitioning from groundwater to vapor phase
- Diffusion in vadose zone
- Advection near building

Important to understand how volatile contaminants move from the source to inside buildings.



Contaminant Partitioning: From Groundwater to Soil Gas

- Partition Coefficient: the relationship between the concentration dissolved in water (Cw) and the concentration in the overlying vapor (Csg)

  Known as the **Henry's Law Constant (H)**

  H = Csg/Cw

- **H** assumes equilibrium and can over-predict concentrations in vapor state

Diffusion and Advection

Diffusion

Advection

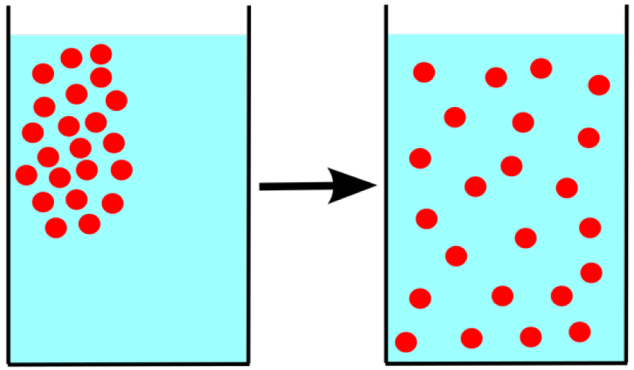
Replacing leaking natural gas line.

Source: G. Todd Ririe

Diffusion

- Contaminants in the vapor phase migrate slowly in the pore space by diffusion

- Vapor phase chemicals move in response to a concentration gradient
  - From high concentration areas to low concentration areas



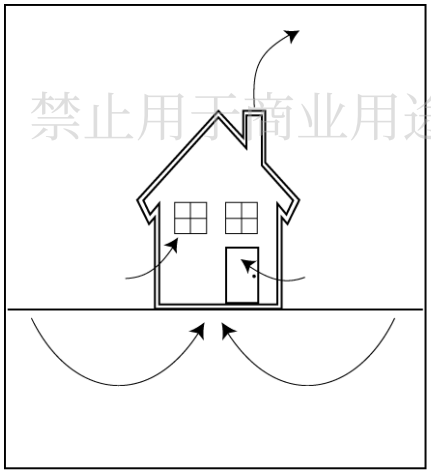
Advection: Much Faster than Diffusion

- Pressure driven gradient
  - Wind speed
  - Barometric pressure changes
  - HVAC (Heating, ventilation, air conditioning) and fan operations
  - Stack effect
- Methane gas generation: displaces other gases, typically associated with landfills

Factors Affecting Movement in the Vapor Phase

Rainfall - Infiltration may displace soil-gas containing VOCs 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

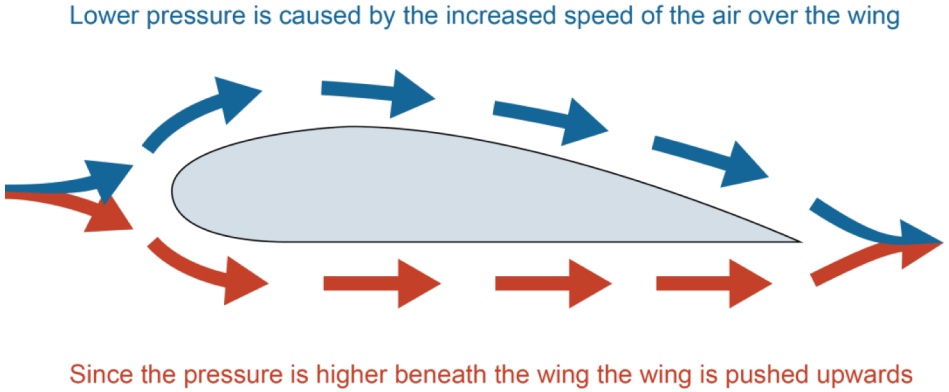


Wind and Barometric Fluctuation - Inside pressure relative to outside pressure

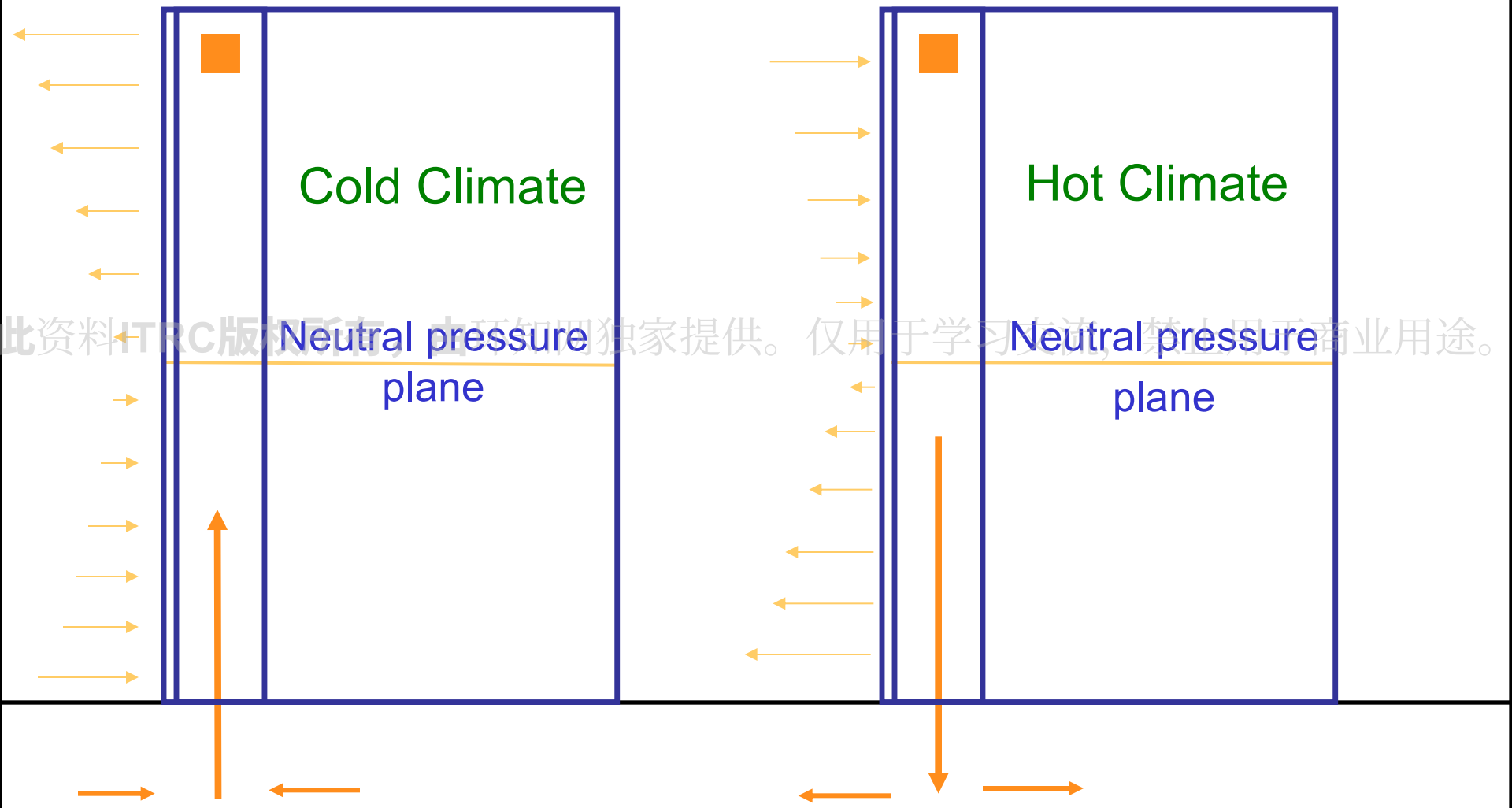
Source: Figures from Massachusetts DEP

Bernoulli's Principle

- Bernoulli's principle states that an increase in a fluid's speed creates a pressure decrease and a decrease in a fluid's speed creates a pressure increase.

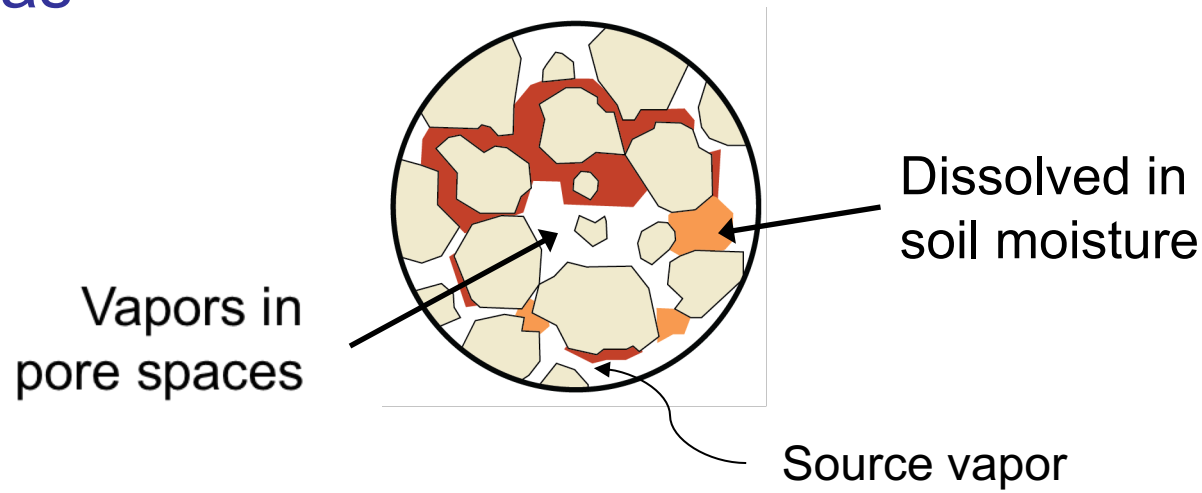


Tall Buildings



Other Factors That Effect Soil Gas Movement

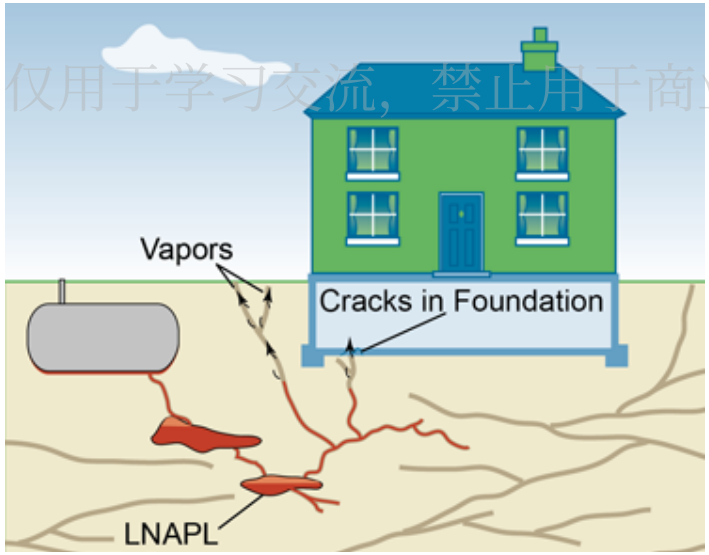
- Porosity: Open Spaces in Rocks/Soils
- Permeability: Measure of ease of movement of gas
- Soil Moisture: Pores filled with moisture displaces gas



Vapor Intrusion (VI) can occur via Preferential Pathways

- Site conditions that result in significant lateral transport or enhanced advective flow

Anthropogenic



Fractured or karst geology

Attenuation Factor Concept

$\alpha_{sg} = C_{indoor}/C_{sg}$

Alpha = 10/500

Alpha = 0.02 (shallow soil gas)

Attenuation (Alpha) Factors

$\alpha_{sg} = C_{indoor}/C_{sg}$ *for soil gas to indoor air*

$\alpha_{gw} = C_{indoor}/(C_{gw}*H)$ *for groundwater to indoor air*

Lower alpha means higher attenuation

Variation in current regulatory VI guidance:

NJ α_{sg} = 0.02 for sub-slab

CA α_{sg} = 0.01 for sub-slab

EPA α_{sg} = 0.03 for sub-slab

Unit Conversion Table

Soil Gas Unit Comparison

Units	Convert to	Multiply by
µg/L	mg/m^3	1
$\mu g/m^3$	mg/m^3	0.001
ppbv	$\mu g/m^3$	MW/24
$\mu g/m^3$	ppbv	24/MW
ppmv	mg/m^3	MW/24
ppbv	mg/m^3	MW/24,000
µg/L	$\mu g/m^3$	1000
$\mu g/m^3$	µg/L	0.001
µg/L	ppbv	24,000/MW
µg/L	ppmv	24/MW
ppbv	ppmv	0.001
ppmv	ppbv	1000

MW - molecular weight
mg/m^3 - milligrams per cubic meter
$\mu g/m^3$ - micrograms per cubic meter
µg/L - micrograms per liter
ppbv - parts per billion by volume
ppmv - parts per million by volume

Converting Analytical Results

$ppbv = (\mu g/m^3 \times 24.45) / MW$

$\mu g/m^3 = (ppbv \times MW) / 24.45$

MW - Molecular weight of the compound
Formulas are chemical-specific

Units of Confusion

Preliminary Screening Evaluations for Soil Gas					
Analyte	Sample Name (sample with the maximum concentration)	Concentration µg/m³	Default Attenuation Factor	Indoor Air Concentration (µg/m³)	OEHHA Chronic Inhalation RELs (µg/m³)
→ **Benzene**	VP-1-25	**1,200**	0.001	1.20	60
Toluene	VP-2-25	420	0.001	0.42	300
Ethylbenzene	VP-6-25	30	0.001	0.03	2,000

The error in Table 7 is off (high) by a factor of over 3000 times

TABLE 7

J&E MODEL RESULTS

Advanced Soil Gas Screening Model				
Analyte	Sample Name (sample with the maximum concentration)	Concentration ppmv	Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
→ **Benzene**	VP-1-25	**1,200**	0.0019	19.0

Keeping the Public Informed

- VI investigation can be disconcerting and intrusive to the public
- Be prepared to address VI-specific concerns and questions that are likely to arise during any phase of investigation, mitigation, or remediation