The Soil Vapor Intrusion Pathway:
A Developing Landscape

Background Indoor Air Levels of Volatile Organic Compounds (VOCs) and Air-Phase Petroleum Hydrocarbons (APH) in Massachusetts Residences

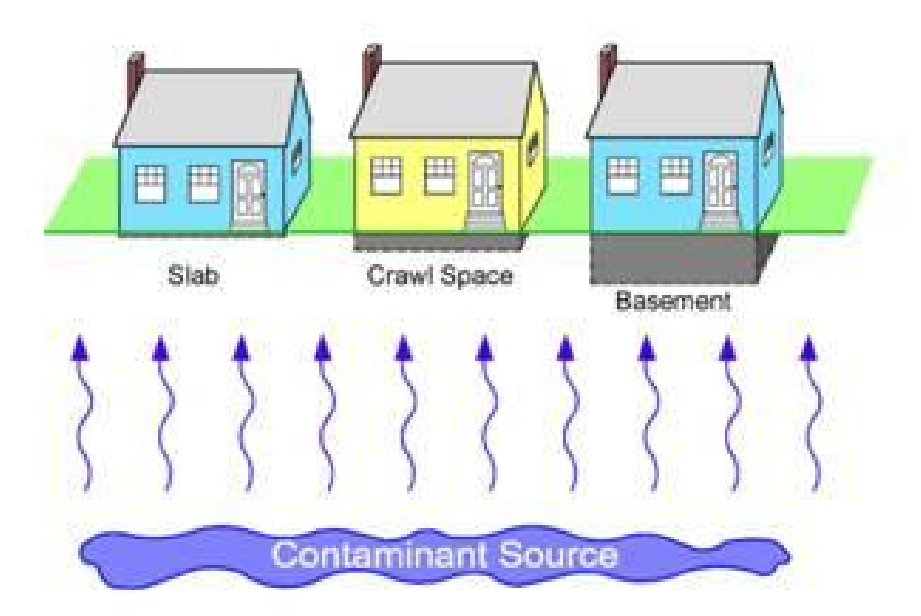
NEWMOA
12 April 2006

Richard J. Rago
Senior Scientist
Haley & Aldrich, Inc.
800 Connecticut Boulevard
East Hartford, Connecticut 06108
Tel: (860)-290-3115
Fax: (860)-282-9500
rrago@haleyaldrich.com

Outline

- Vapor Intrusion Overview
- History of Vapor Intrusion Pathway Evaluation by Various State and Federal Programs
- Indoor Air Sampling Considerations
- Background

Vapor Intrusion to Indoor Air

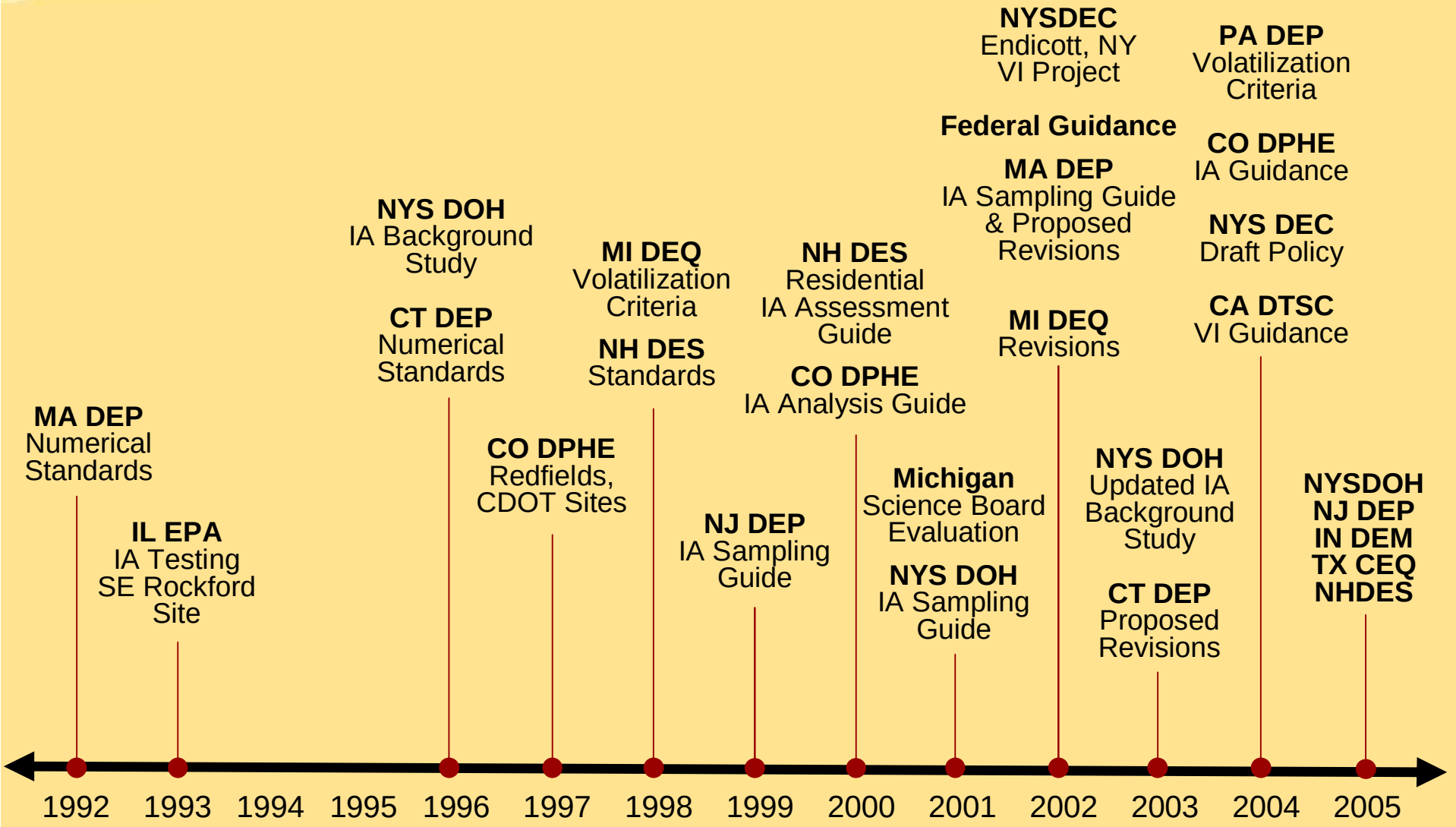


Vapor intrusion is the migration of volatile chemicals from the subsurface into overlying buildings.

Definitions Of Soil Gas

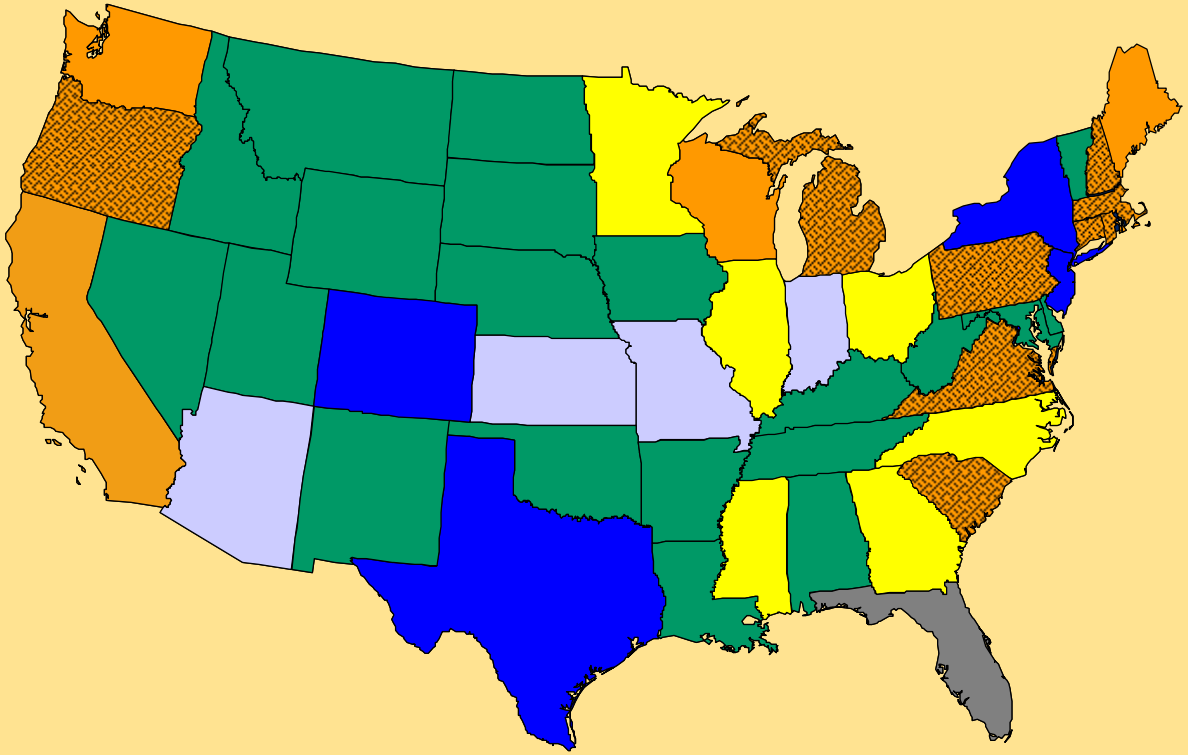
- Gaseous compounds/elements in the spaces between soil particles.
- Vapor that can be extracted from the subsurface, above the water table.
- In uncontaminated areas, a mix of atmospheric gasses (O_2, N_2) and other gasses, such as CO_2 and CH_4.
- In contaminated areas, a combination of naturally occurring and other gasses.

History of VI Guidance Development



State Vapor Intrusion Guidance

- Not evaluated
- Defers to federal program
- Developed/developing program with varied flexibility
- Developed program with varied flexibility, including numerical standards/screening criteria
- Conservative program with substantial regulatory oversight
- Currently developing guidance
- No guidance; pathway not evaluated currently

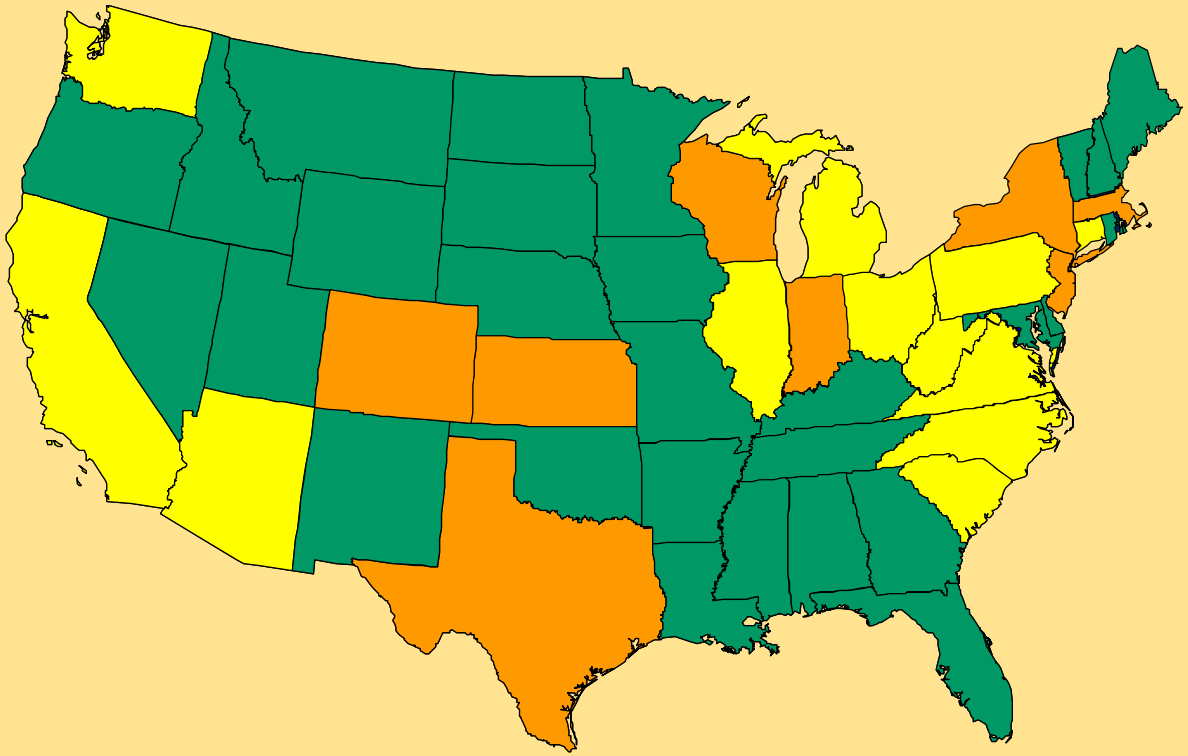


State Vapor Intrusion Guidance

- **Conservative state program with substantial regulatory oversight**
  - Colorado (review)
  - Kansas (developing)
  - New Jersey (review)
  - New York (review)
  - Texas (developing)
- **Defers to federal program**
  - Alaska (developing)
  - Georgia
  - Illinois
  - Indiana (developing)
  - Minnesota (non-LUST)
  - Mississippi
  - North Carolina
  - Ohio
- **State program with varied flexibility**
  - Arizona (developing)
  - California (review)
  - ***Connecticut (revision)***
  - ***Massachusetts (revision)***
  - ***Michigan (revision)***
  - ***New Hampshire***
  - ***Oregon***
  - ***Pennsylvania***
  - ***Rhode Island***
  - ***South Carolina***
  - ***Virginia***
  - Washington
  - Wisconsin

States in italics have developed volatilization standards or screening criteria for groundwater, soil and/or soil vapor.

Preference for Measurement vs. Modeling

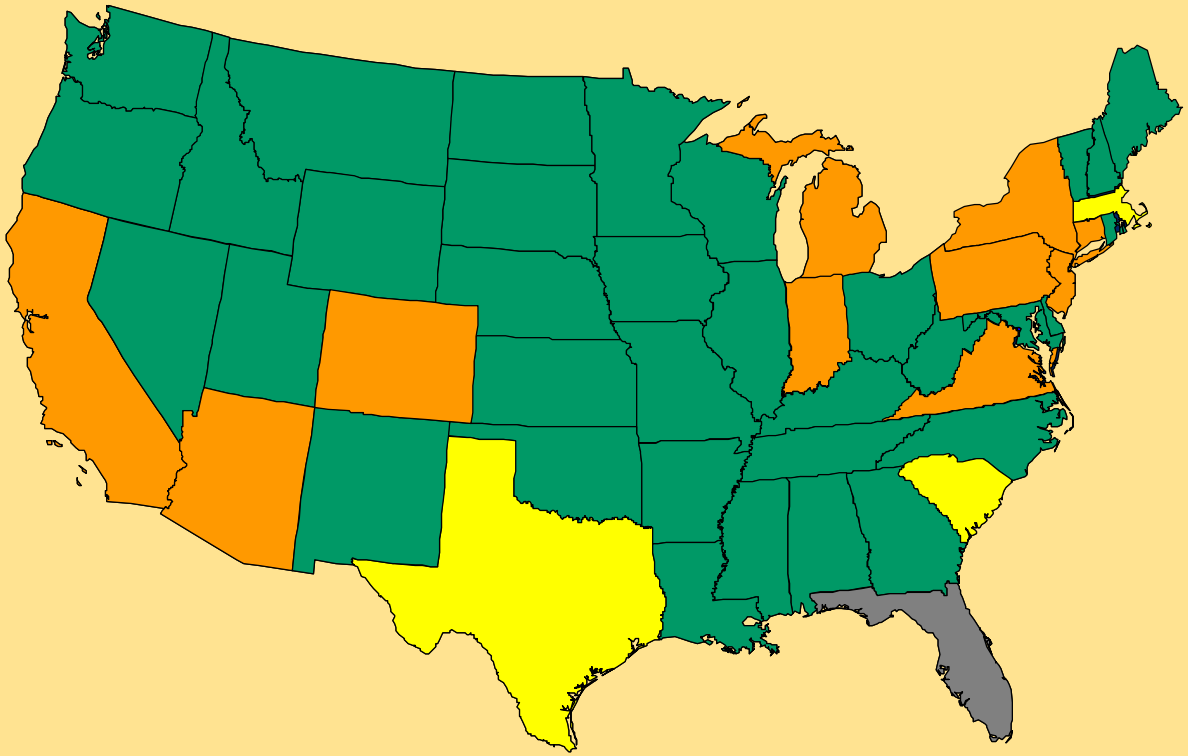


Not evaluated

Modeling recommended prior to indoor measurements (federal approach)

Indoor air or sub-slab measurements desired

Future Use Considered



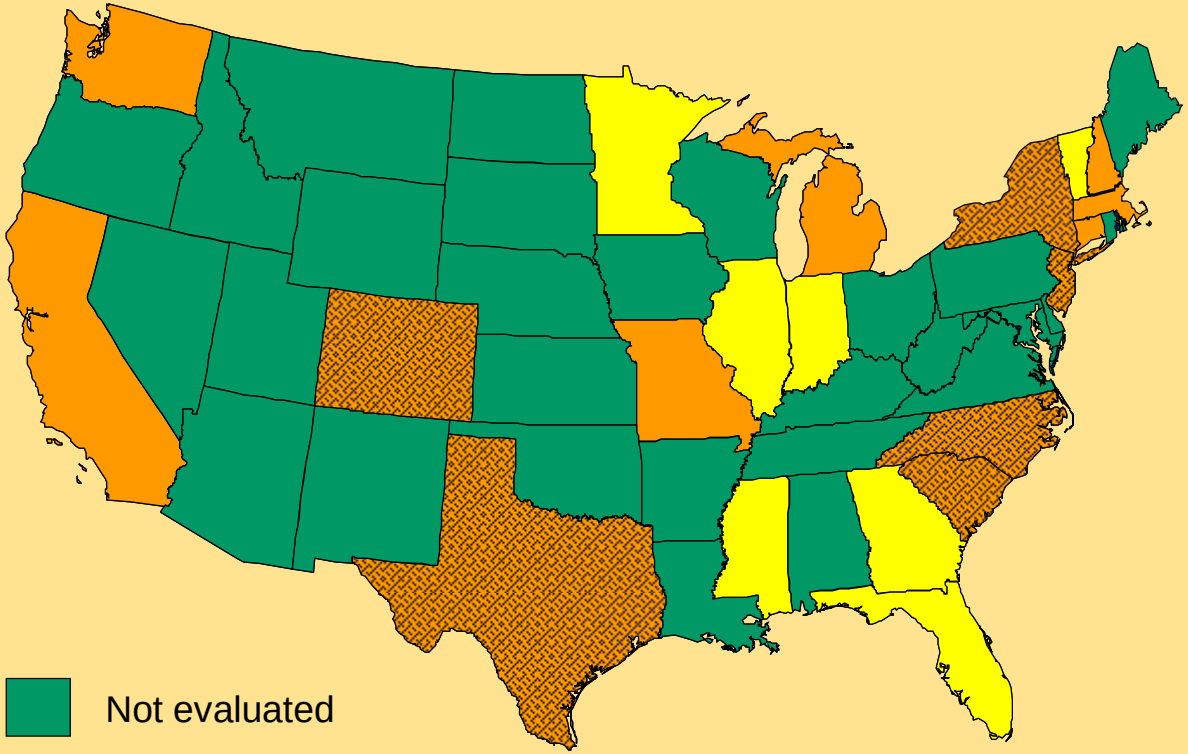
Not evaluated

Current site use or known future use only

Hypothetical future use considered

Not applicable; pathway not evaluated currently

OSHA Applicability



Not evaluated

OSHA regulates workplace (current federal position)

Hazardous waste program regulates workplace

Hazardous waste program regulates if subsurface VOCs differ from workplace; OSHA regulates if subsurface VOCs are same as workplace

Attributes of MA, NY, and NJ Guidance

	MA	NY	NJ
Trigger distance (feet)	GW: 30H; 15V Soil: 6H; 10V	100	100H; 30V
Modeling vs. Measurement	Measurement	Measurement	Measurement
Numerical criteria	GW	IA (5 compounds)	IA, possibly SV and GW
Background #s incorporated?	Yes	Yes	No
Analyte list	Site-related	SV: "wide range" IA: site-related	Full suite TO-15
Outdoor air sampling?	Yes	Yes	Yes
Hypothetical future use?	No	Yes	Yes

When to Collect the Sample?

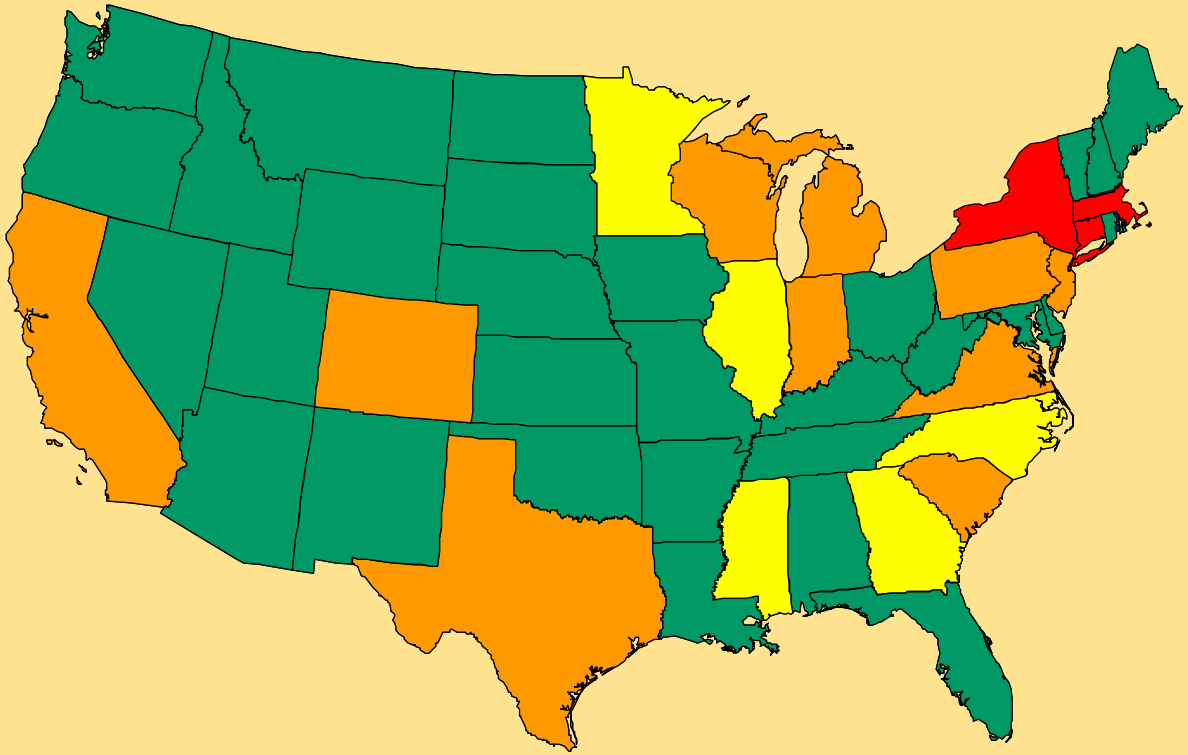
Parameter	Most Conservative	Least Conservative
Season	Late winter/early spring	Summer
Temperature	Indoor 10°F > Outdoor	Indoor < Outdoor
Wind	Steady > 5 mph	Calm
Soil	Saturated with rain	Dry
Doors/Windows	Closed	Open
Mechanical Heating System	Operating	Off
Mechanical Fans	Off	On

(Indoor Air Sampling and Evaluation Guide, MADEP, April 2002)

What is Indoor Air Background?

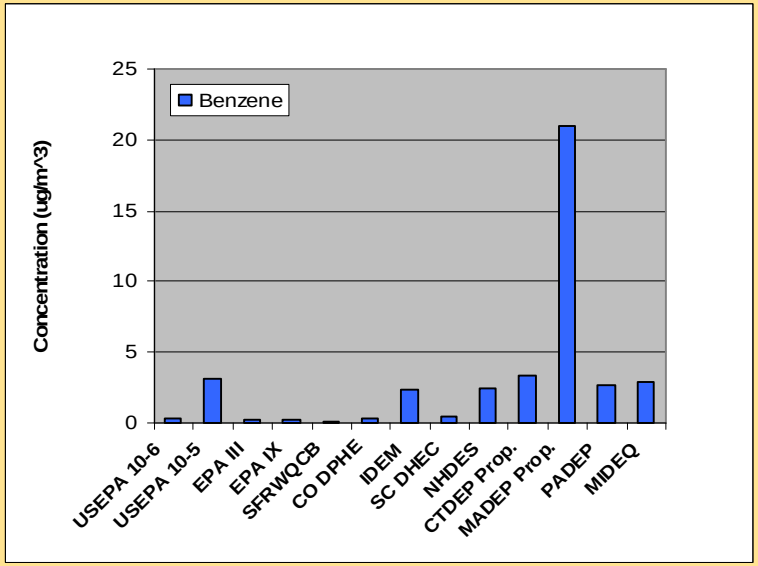
- Things that are present at a site in the absence of a release
- Can differ from residence to residence
- May be naturally occurring or anthropogenic
  - Mold, Moisture, Radon
  - Pet allergens
  - Carbon dioxide and Carbon monoxide
  - VOCs/SVOCs
  - Asbestos and Particulates
  - More

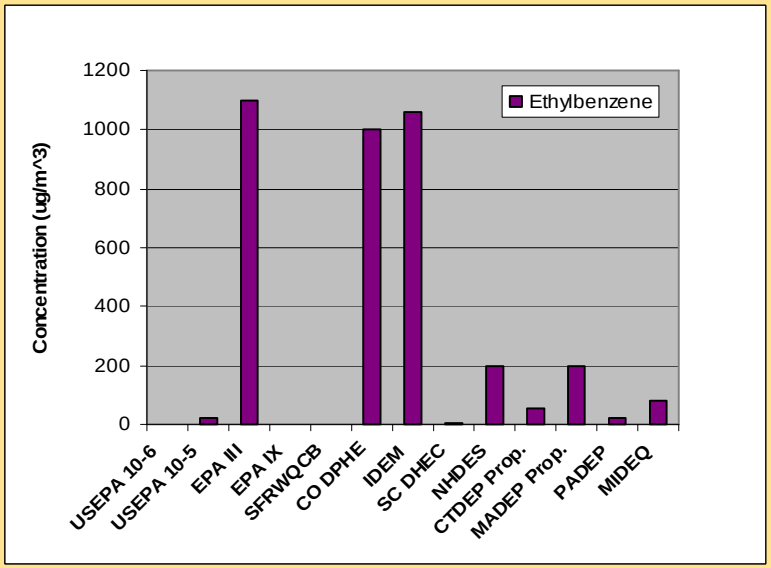
States Utilizing Indoor Air Background

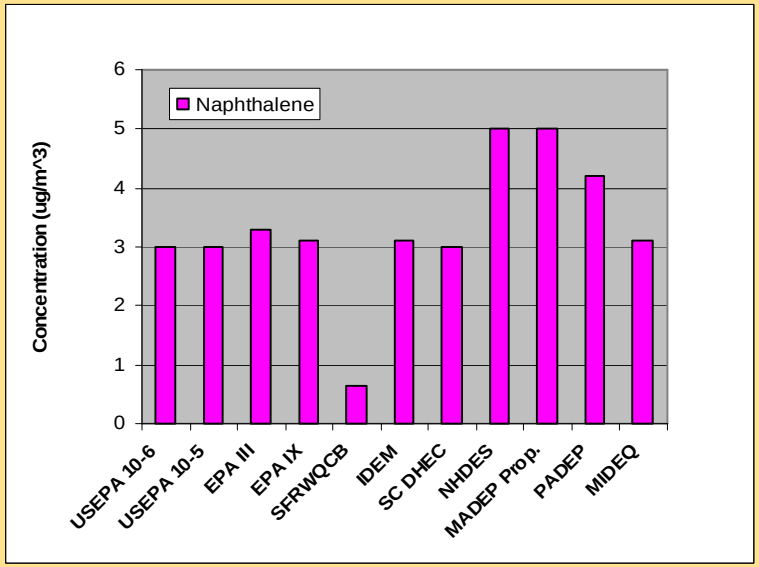


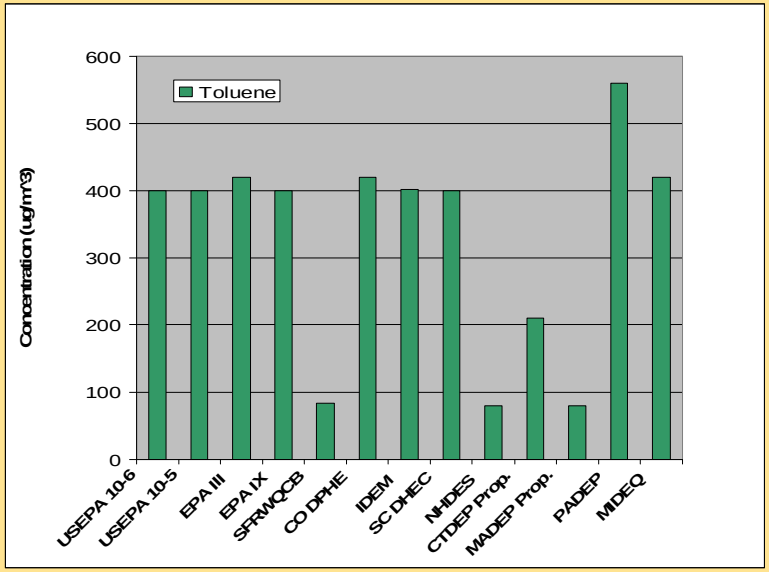
- Not reviewed, VI guidance does not currently exist, or background not considered
- Indoor air background considered quantitatively (in standards or evaluation)
- Indoor air background considered qualitatively (Weight of Evidence approach)
- Defers to federal program (background considered but included in Risk Assessment)

Target Residential Indoor Air Concentrations

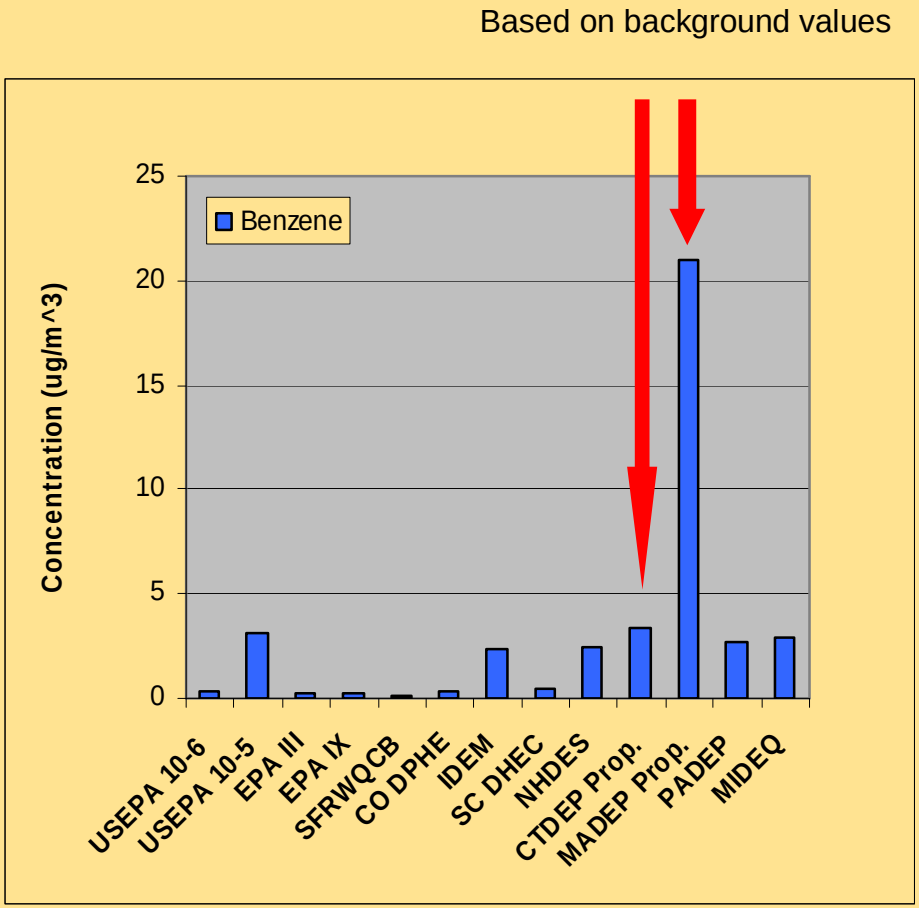








Why is there Variability in Regulatory Indoor Air Target Concentrations?



- Background values
- Background references
- Target risk levels
- Toxicity factors
- Odor thresholds
- Analytical quantitation limits
- Exposure factors (i.e., exposure duration, inhalation rate, body weight)

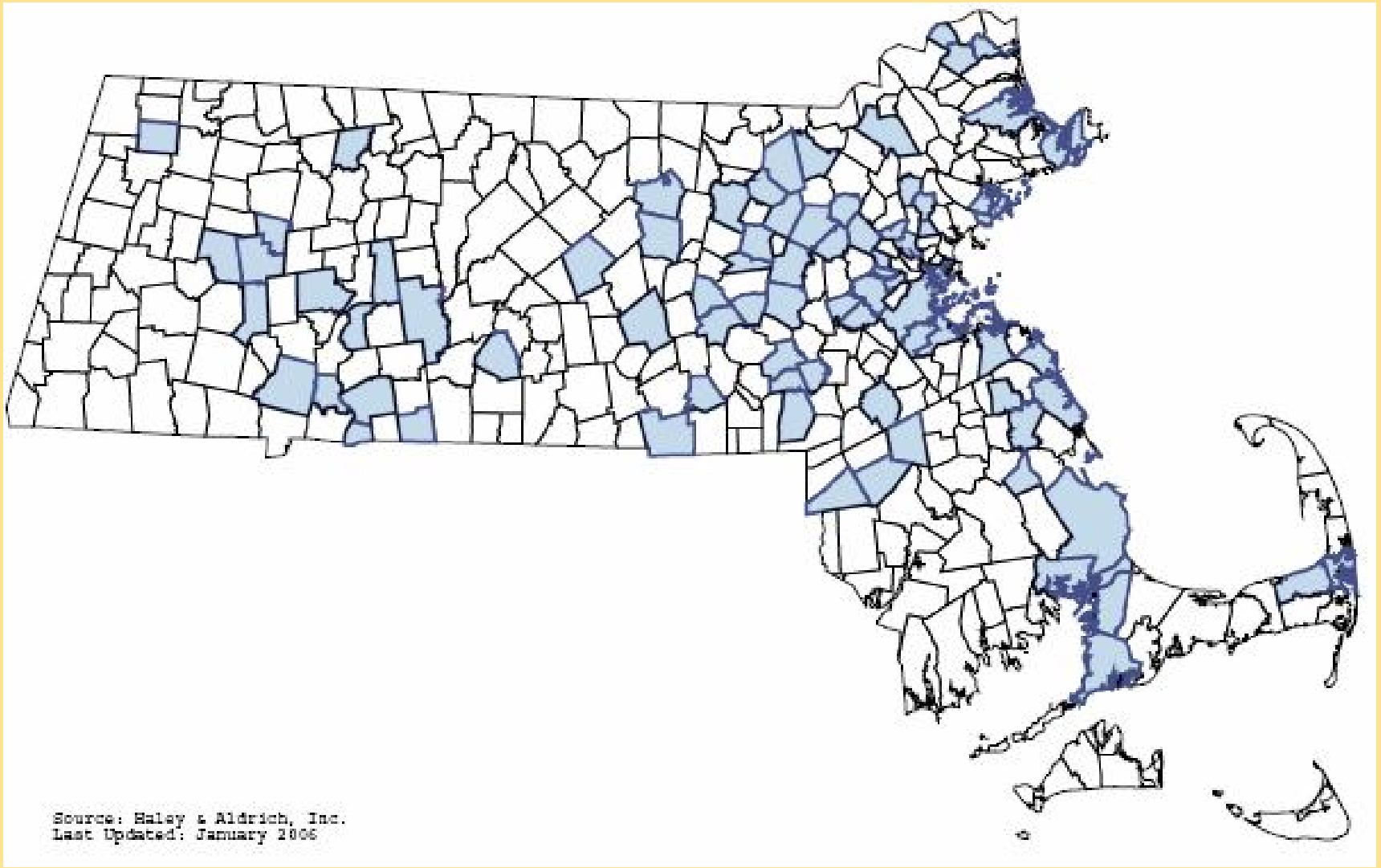
Indoor Air Background – Existing Literature Data

- Shah & Sing/EPA National Ambient VOC Database (1988)
- Stolwijk (1990)
- Vermont (1992)
- MADEP (2002)
- Kurtz & Folkes (2002)
- NYSDOH (2003)
- Ohura et al (2004)
- Adgate et al (2004)

Massachusetts Indoor Air Background Study

- Objective: To obtain background concentrations of Air-Phase Petroleum Hydrocarbons (APH) and Volatile Organic Compounds (VOCs) in the living space of Massachusetts residences
- Funded by Haley & Aldrich, Inc. and Alpha Analytical Labs, Inc.
- Sought and obtained EPA Region I and MA DEP study design review, input, and acceptance
- Implemented with support of LSPA Technical Practices Committee, a Massachusetts-based group of environmental professionals

Indoor Air Sample Locations 2004-2005



Top 11 Compounds Detected

COMPOUND	FREQUENCY OF DETECTION	MINIMUM DETECTED CONCENTRATION (ug/m3)	MAXIMUM DETECTED CONCENTRATION (ug/m3)	MEDIAN CONCENTRATIONS (ug/m3)	UPPER QUARTILE (75TH PERCENT) (ug/m3)	UPPER QUARTILE (90TH PERCENT) (ug/m3)
		2004 -2005 MA RESIDENTIAL IAQ STUDY PRELIMINARY RESULTS				
ETHYL ALCOHOL	100 / 100	16.8	7290	286	676	1673
ACETONE	97 / 100	4.89	257	26.5	41.4	61.6
ISOPROPYL ALCOHOL	92 / 100	1.26	443	10.1	29.5	89.7
TOLUENE	90 / 100	1.99	944	7.6	17.9	42.5
C5-C8 ALIPHATICS	83 / 100	24.9	1240	58	125	329
C9-C12 ALIPHATICS	80 / 100	28.4	3480	68	110	222
2-BUTANONE	79 / 100	30	3270	2.7	4.0	9.6
CHLOROMETHANE	79 / 100	1.04	4.21	1.2	1.4	1.8
ETHYL ACETATE	52 / 100	1.96	32	2.3	5.9	9.8
M/P-XYLENE	52 / 100	2.54	81.9	3.0	7.4	21
MTBE	46 / 100	2.54	155	1.8	6.9	38

NOTE: MA DEP RECOMMENDED BACKGROUND VALUES ARE AVAILABLE FOR 7 OF THESE 10 COMPOUNDS.

11 Interesting Compounds

COMPOUND	2004-2005 MA RESIDENTIAL IAQ STUDY PRELIMINARY RESULTS						MA DEP RECOMMENDED BACKGROUND VALUES (ug/m3)
	FREQ. OF DETECTION	MINIMUM DETECTED CONC. (ug/m3)	MAXIMUM DETECTED CONC. (ug/m3)	MEDIAN (50TH PERCENT) (ug/m3)	UPPER QUARTILE (75TH PERCENT) (ug/m3)	UPPER QUARTILE (90TH PERCENT) (ug/m3)	
C5-C8 ALIPHATICS	83 / 100	24.9	1240	58	125	329	85
C9-C12 ALIPHATICS	80 / 100	28.4	3480	68	110	222	90
ACETONE	97 / 100	4.89	257	26.5	41.4	61.6	27.04
BENZENE	31 / 100	1.6	28.1	2.0	1.9	6.8	2.1
TOLUENE	90 / 100	1.99	944	7.6	17.9	42.5	28.65
ETHYLBENZENE	19 / 100	2.01	30	2.2	2.1	4.60	9.62
M/P-XYLENE	52 / 100	2.54	81.9	3.0	7.4	21	40**
O-XYLENE	29 / 100	2.2	2.3	2.2	2.4	6.8	10**
METHYL TERT-BUTYL ETHER	46 / 100	2.54	155	1.8	6.9	38	3-18*
TETRACHLORCETHYLENE	5 / 100	6.20	27.6	3.4	3.4	3.4	11.01
TRICHLORCETHYLENE	2 / 100	3.84	110	2.7	2.7	2.7	4.49

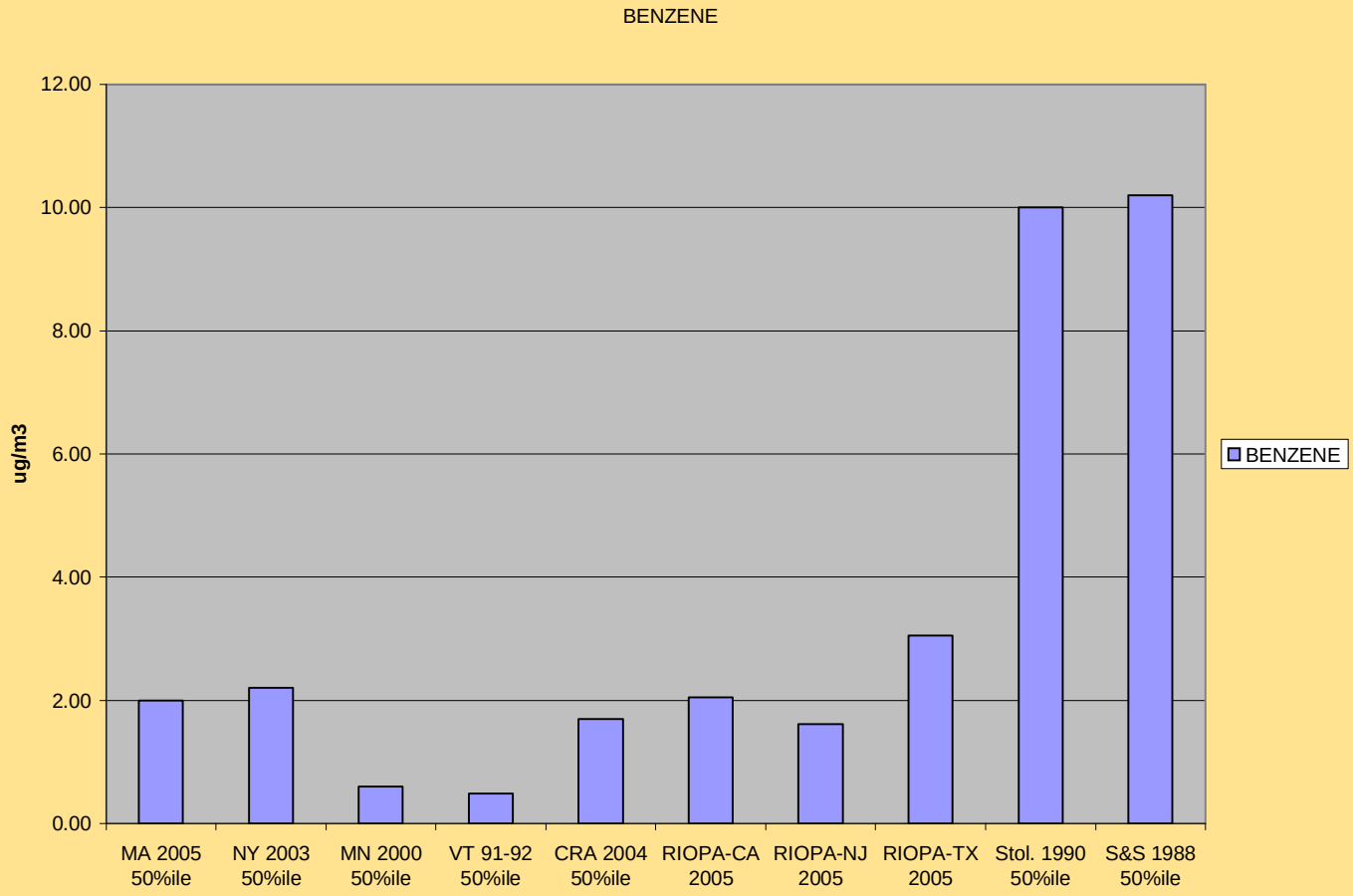
**: the MA DEP provides a range for the methyl tert-butyl ether background value*

***: these background values are from the Stolwijk paper. MA DEP using a xylenes, mixture background value of 72.4 ug/m3*

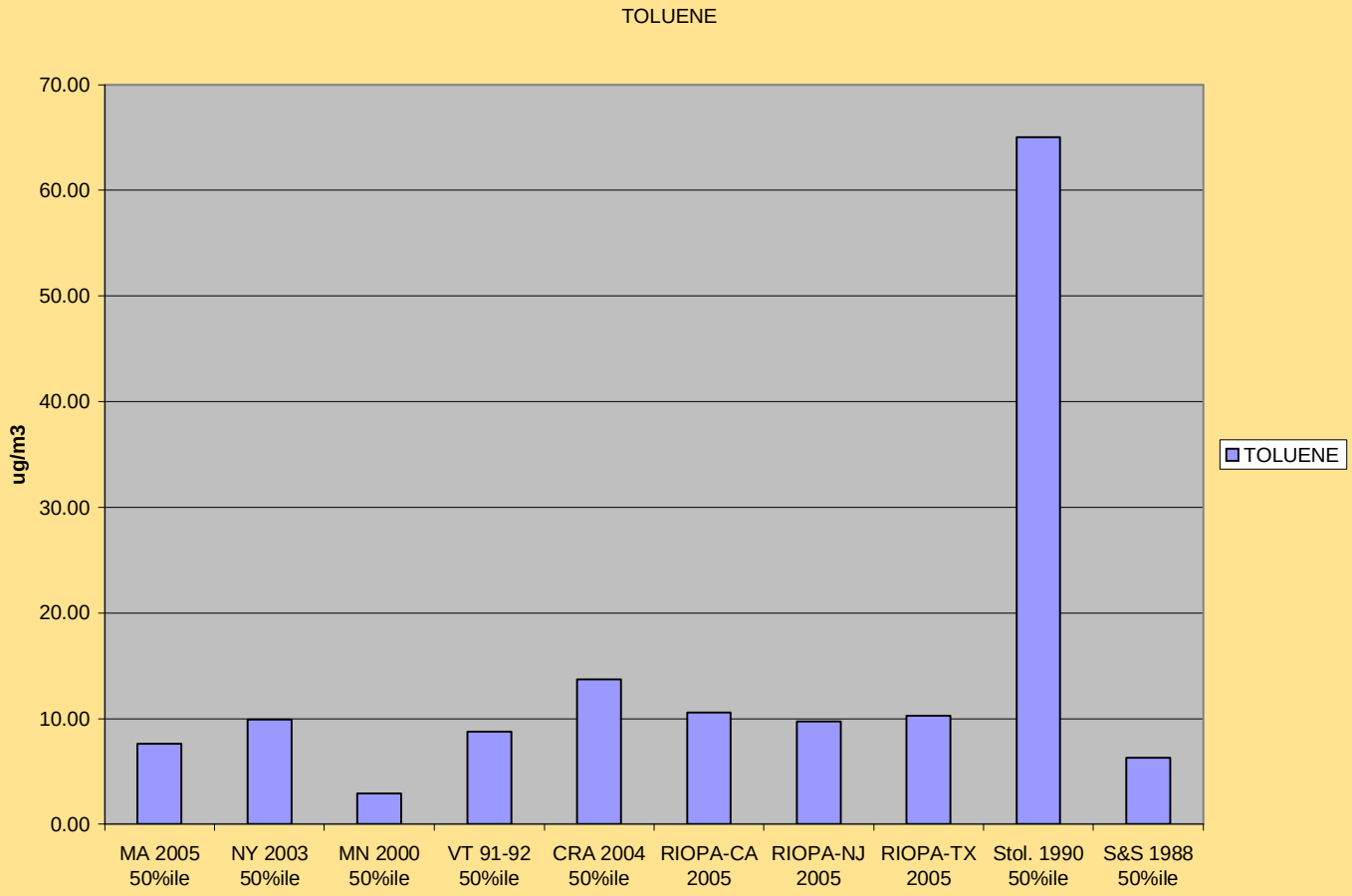
Naphthalene

- Naphthalene is listed as target compound in the MA “APH” method, also tested by Haley & Aldrich in 100 samples. Naphthalene is not listed in the TO-15 method (perception of poor method recoveries).
- Naphthalene detected in 16 of 100 APH samples, ranging from 2.12 ug/m3 to 41.5 ug/m3.
- Of 16 samples:
  - six were homes with natural gas heat
  - nine were in homes with oil heat
  - one was a home heated by propane
- The three highest naphthalene concentrations were detected in samples collected in homes heated with oil.

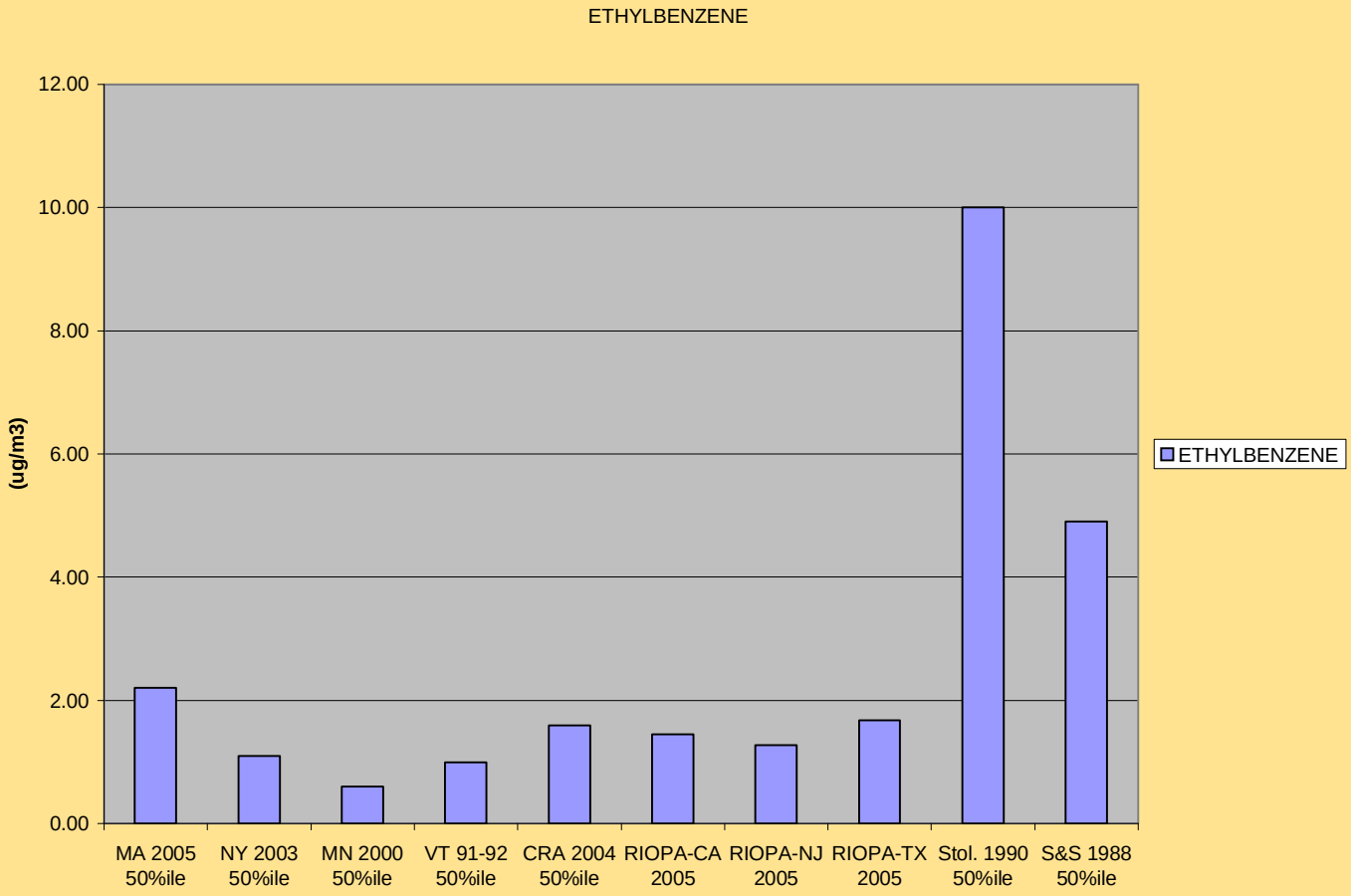
Benzene Background Comparison



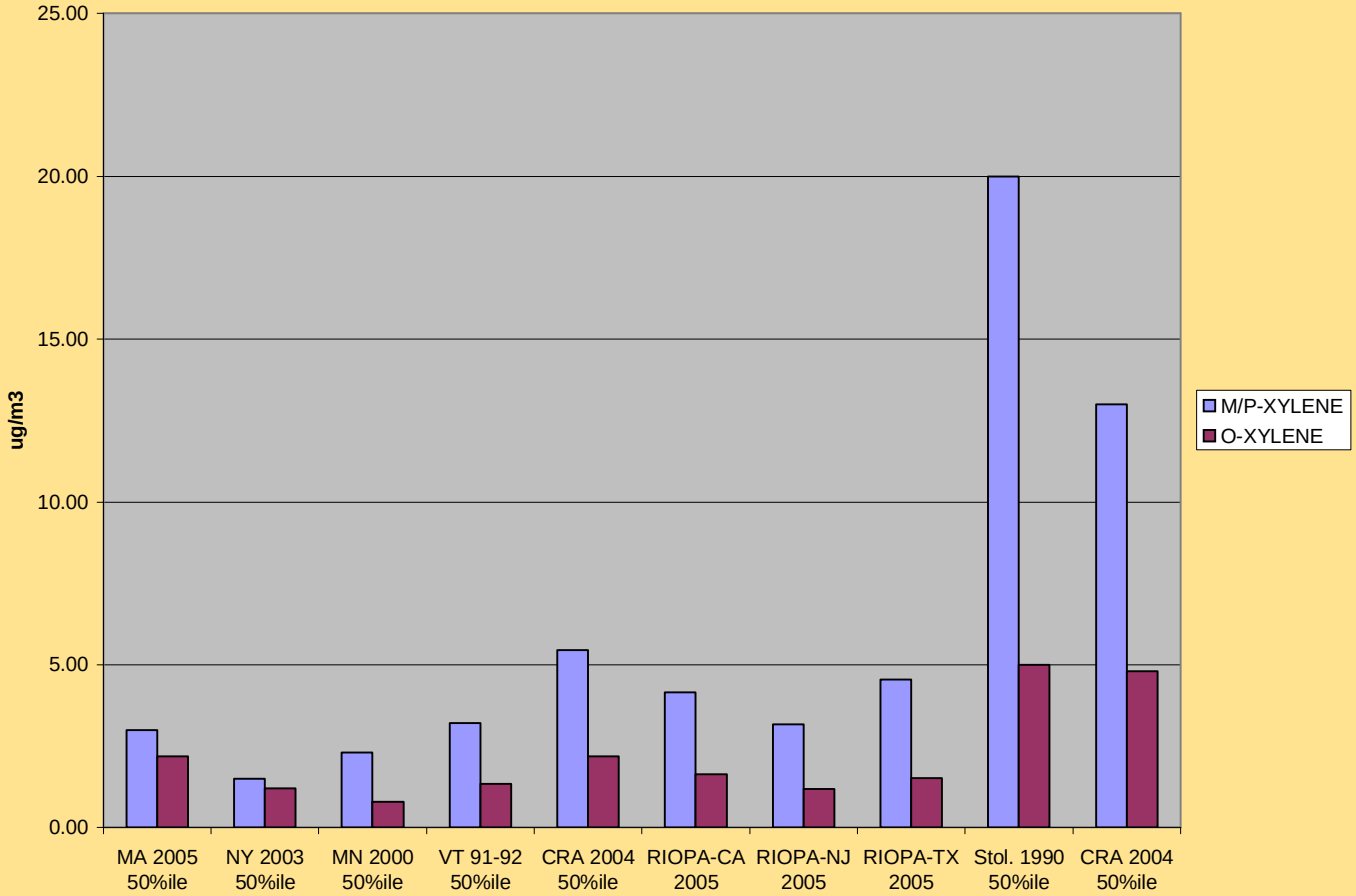
Toluene Background Comparison



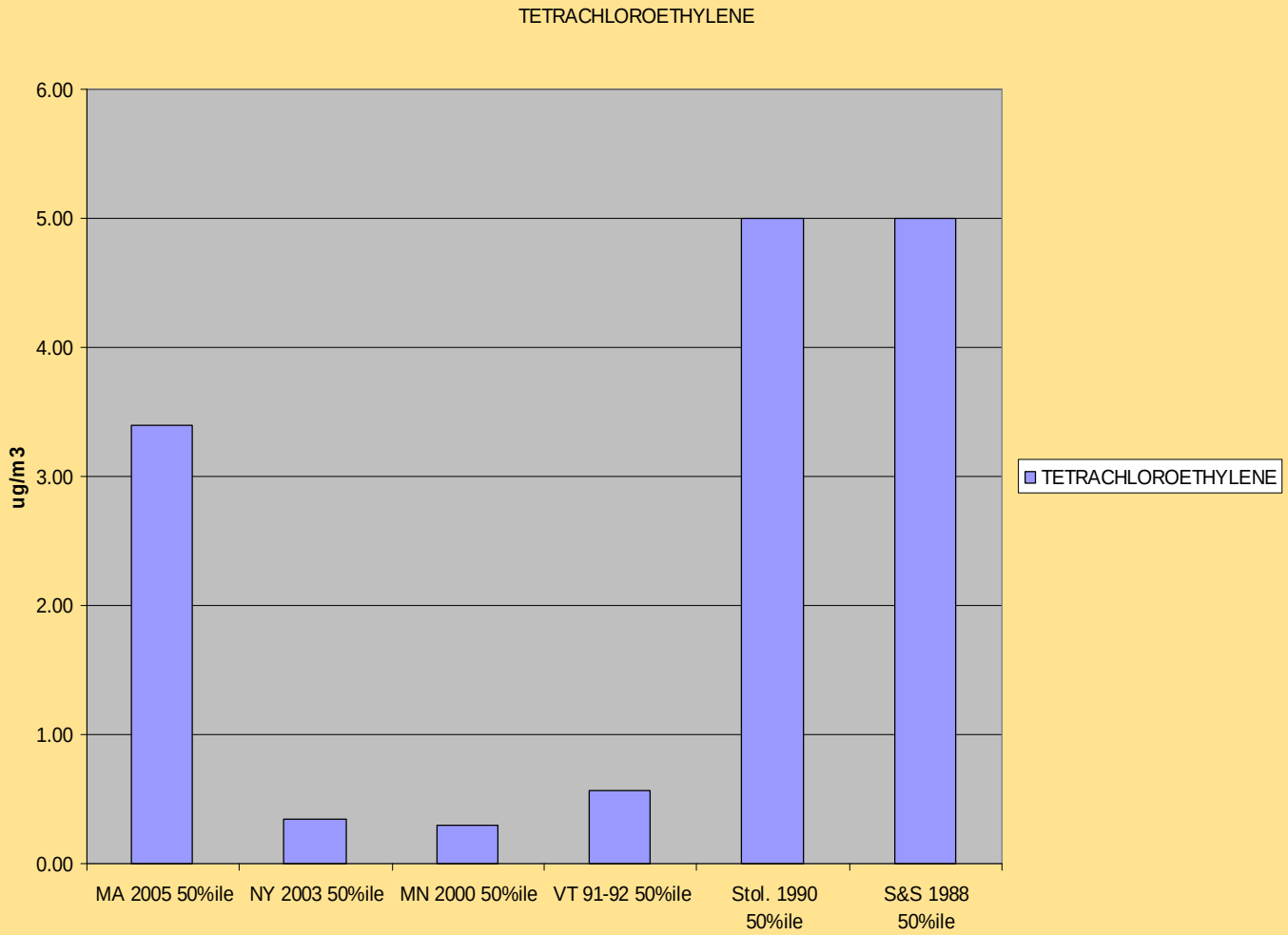
Ethylbenzene Background Comparison



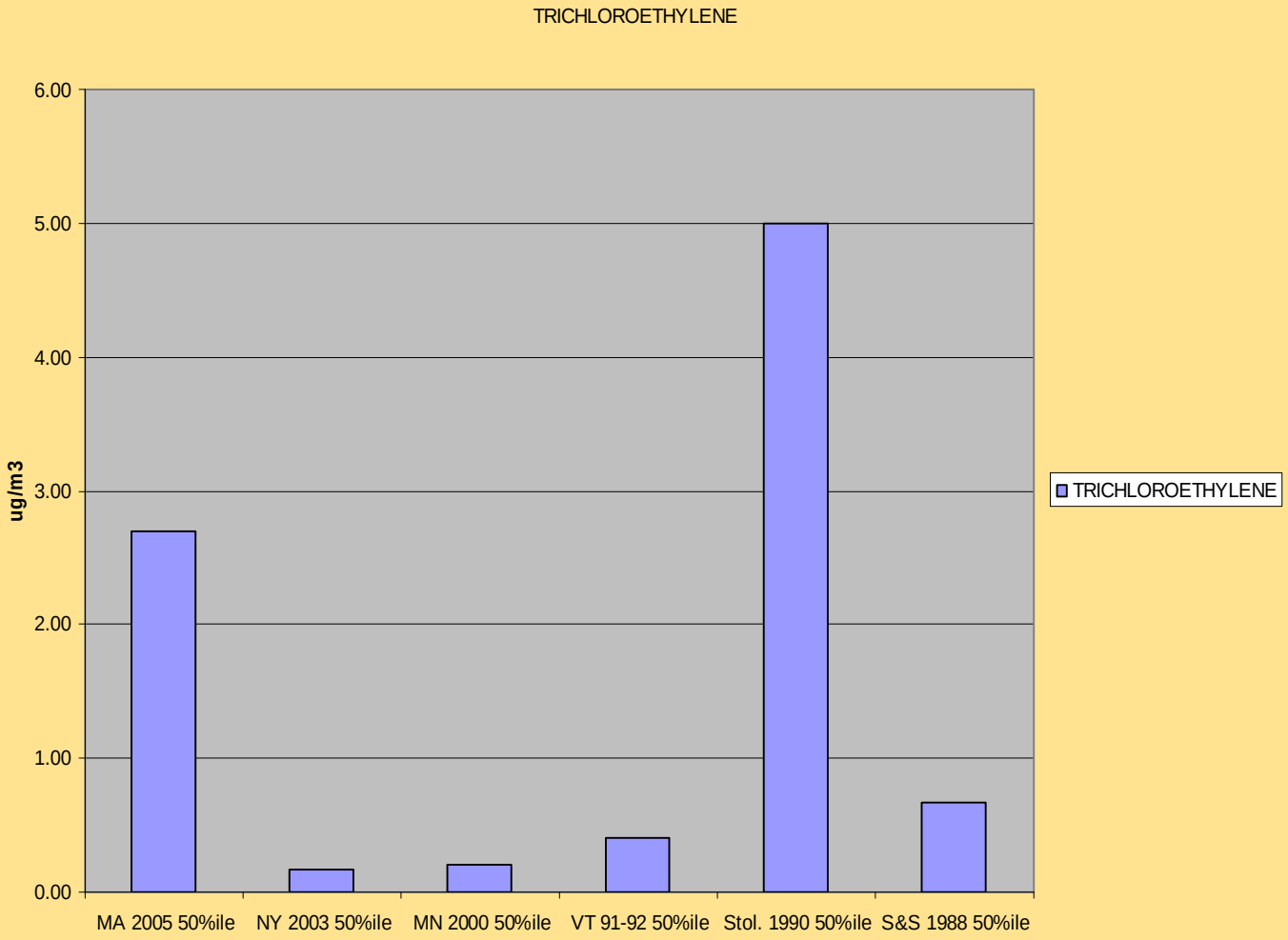
m/p-Xylene and o-Xylene Background Comparison



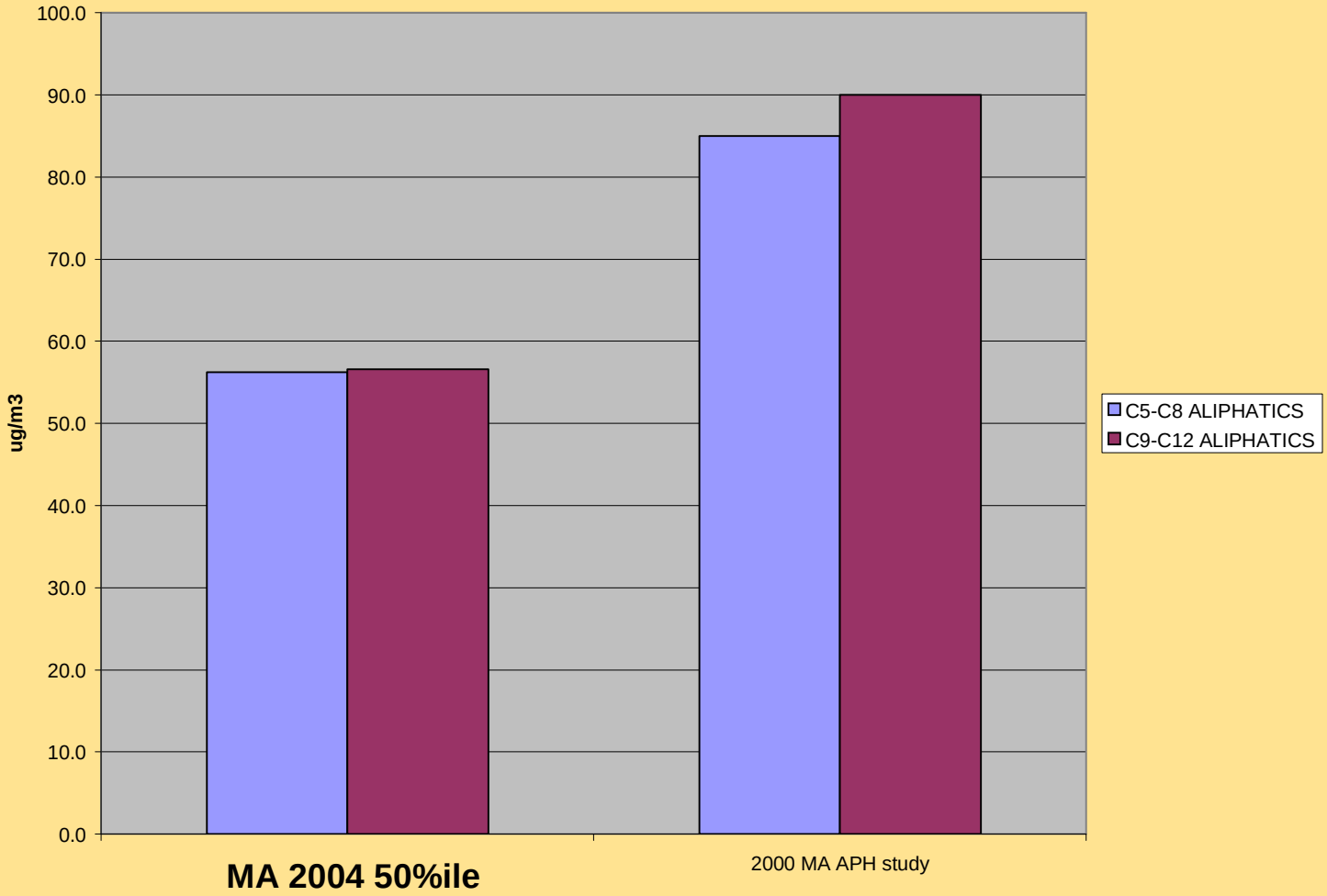
Tetrachloroethylene Background Comparison (2004-2005)



Trichloroethylene Background Comparison (2004-2005)



APH Background Comparison (2004)



Handling of non-positive results (non-detected values)

- Use of whole reporting limits for “normal” low level TO-15 (RL ~ 0.5 ppbV)
- Use of one half the reporting limits for “normal” low level TO-15 (RL ~ 0.5 ppbV)
- Use of whole or one half the reporting limits for “SIM” TO-15
- (NYDOH) substitution of randomly generated values for non-detect values less that 0.25 micrograms per cubic meter (0.43 micrograms per cubic meter for hexachlorobutadiene)
- Helsel approach

What's Next?

- Data submitted to EPA and MA DEP
  - Publication of study
    - Statistically evaluate distribution of data
  - Determine relationships between concentrations and possible indoor sources
    - Fuel source
    - Attached Garages
    - Smoking
    - Home construction
    - Population

Summary/Potential Data Application

- Indoor air background is very personal
- Indoor air background can and does change
- Use this preliminary data with caution
  - should not be applied blindly
  - these are residential values
  - snapshot data
- Carefully review background studies for focus
- Background data may be useful in evaluating extent of subsurface contamination
- Background data may be considered in calculating clean up criteria

Summary

- Management of VI sites may be challenging and sometimes inconsistent, unpredictable, and resource-intensive
- Focus in United States tends to be on chlorinated VOCs
- Regulators and consultants are still grappling with petroleum hydrocarbons due to biodegradation and background
- Future trends include more soil gas sampling, proactive installation of vapor mitigation systems in lieu of sampling, collection of biodegradation parameters (O_2, CO_2, vertical profiles)
- Mitigation is often a cost-effective solution, especially when implemented during construction or redevelopment

Thank You

- State and federal vapor intrusion guidance and references can be found at: http://www.haleyaldrich.com/vi%20services.html

- Searchable, indexed database for household products: http://householdproducts.nlm.nih.gov/