Background and Development of **National Guidance** for

Evaluating Subsurface Vapor Intrusion: Interim Guidance for Cleanup Programs

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Technical Support Project General Meeting

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Purpose of today's Discussions

- Review the History of vapor intrusion issue

- Provide an Update of current status of guidance

- To help make the best guidance possible:
  - by reviewing what this guidance **is** (and **is not**)

- To receive comments on tech. & policy issues
  - in today's discussions
  - during on-going OSWER and CA EI conf. calls
  - in written format prior to, or in response to, Fed. Register notice (expected mid. summer)

History

Many important events lead to where we are:

- 1803 Dr. Henry's Law - volatilization of solutes
- 1987 Soilgas tracking plume & radon entry GWMR
- 1989 J. Fitzgerald of MADEP uses OVA inside
- 1990 MA leads nation in responsible treatment, ++
- 1991 Johnson & Ettinger's model published
- 1996 CTDEP finalizes numerical standards
- 1997 Superfund web site with user-friendly J&E
- 1998 API and ASTM issue guidance doc. w/ J&E
- 1999 Many states working on the issue, w/ regs.
- 1999 C. Johnson of Colo. DPH&E presents at Nat.
- 1999 RCRA CA EI guidance issued - freq.footnote
- 1999-00 10-Reg. RCRA CA Workshops w/ vapors

History cont.

Many important events lead to where we are:

- 2000 2-day EI Forum (www.clu-in.org/EIForum2000)
- 2001 2-day Vapor Summit (kick off to guidance)
- 2001 10/23/01 Draft Supplement to EI guidance
  - www.epa.gov/correctiveaction
- Denver Post interviews AA Marianne Horinko
  - Marianne acknowledges volatilization phenomenon
- 2002 2+day Nat. Mtg (www.clu-in.org/EIVapor2002)
- Series of Denver Post articles:
  - Critical of Johnson & Ettinger model (false-negative rates)
  - Recommending Indoor Air sampling (ignoring indoor sources)
- AA - any guidance be for "One Cleanup Program"
- OSWER Immediate Office facilitates revisions

4

BUILDING FOUNDATION & SUBSOIL COMPARTMENT (Near-field)

Building Envelope

ADVECTION

ΔP

Kslab

D **Ksoil**

CONTAMINATION
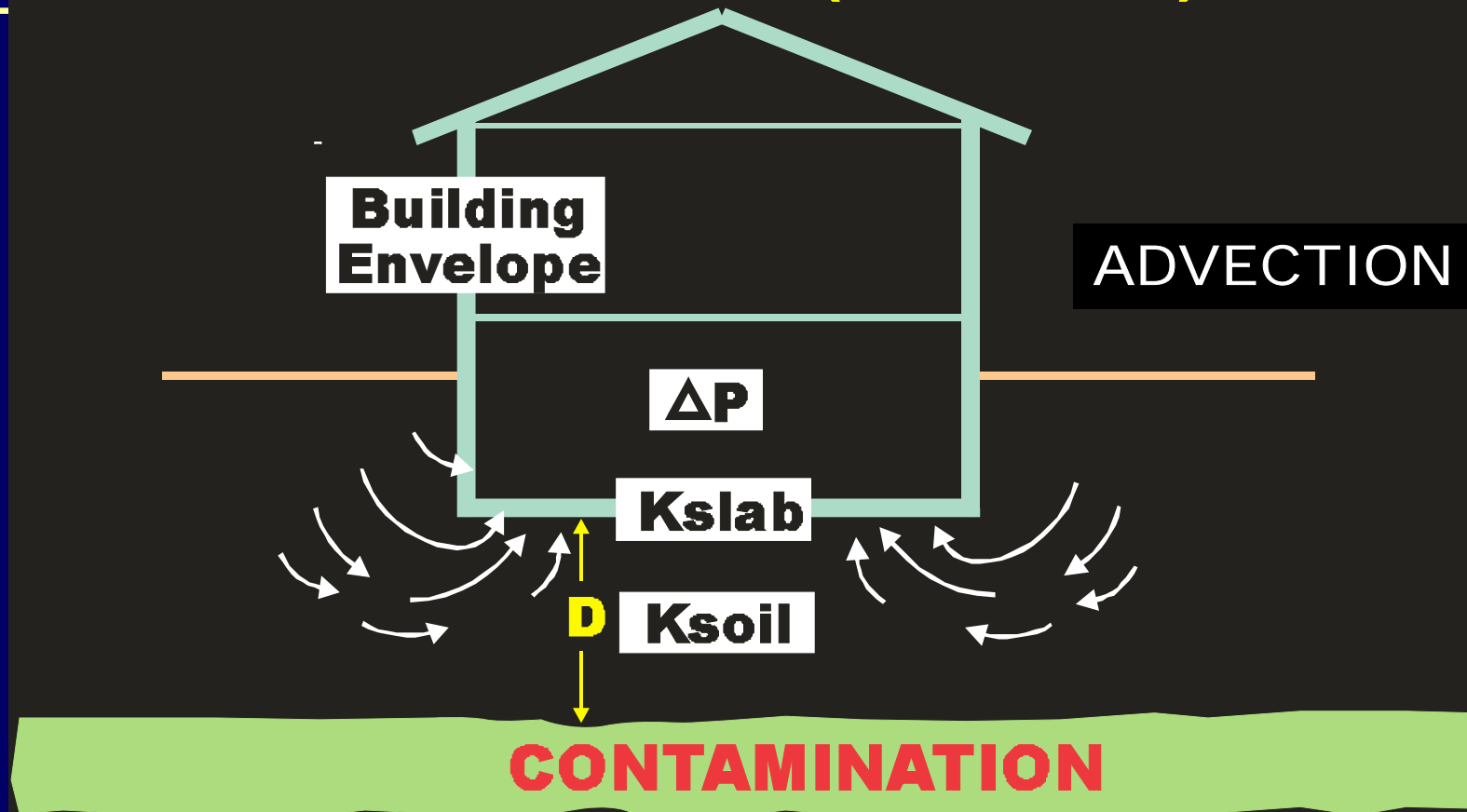
## CONTRIBUTION OF ADVECTIVE FLUX TO VOC INTRUSION GREATEST WHEN

- ΔP, Ksoil, Kslab, high
- D low
- Tight above-grade building envelope

5

7

Colorado sites break 3 Myths

(Charles Johnson's "irresponsible to ignore" evidence)

- **No basements**
  - slab on-grade (crawl spaces)

- **Not PPM concentrations**
  - drinking water levels

- **Not shallow groundwater**
  - 20-30 ft bgs

- Many thousand high-quality indoor air (and groundwater) data points

- Unique subsurface tracer compound 1,1-DCE
  - Not known in products (esp. correlating w/ groundwater)
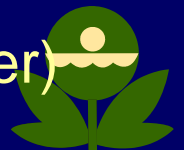
1,1 DCE
(Note: close* correlation w/ gw std)
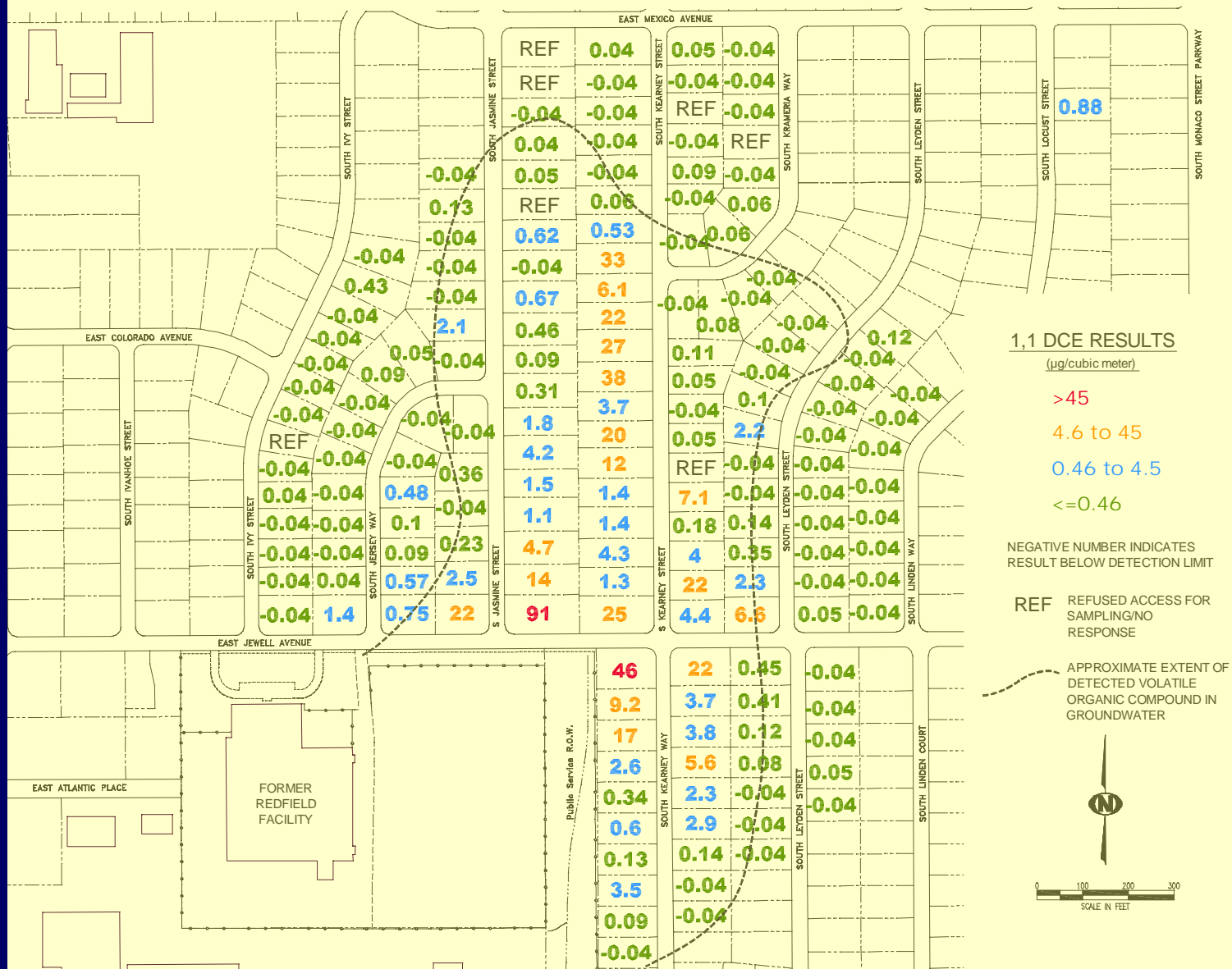
Acknowledgement of Slides Stolen from earlier presentations:

- **Ian Hers, UBC/Golder, Vancouver, BC**
  - **House with flow lines**

- **David Folkes**, Enviro-group, Denver
  - Maps of 11-DCE distributions, & Radon Systems

- **Rex Bryan**, PhD, Of DynCorp, Golden Colo.,
  - Statistical Analysis of CDOT data

- **Jeff Kurtz**, Environ. Mining Sys. Inc, Denver
  - TCE Background view from Redfield
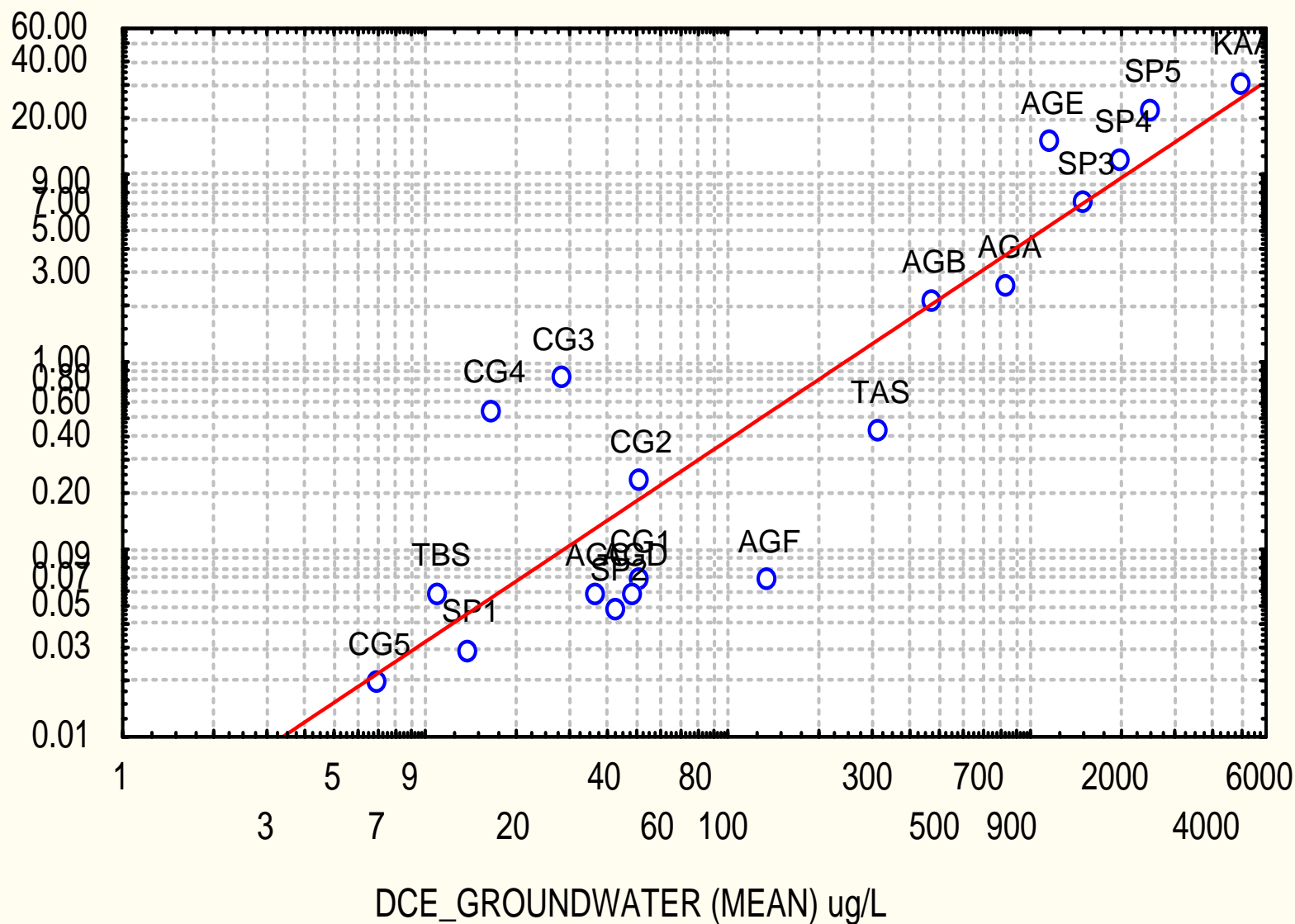
DCE_GROUNDWATER vs. DCE_INDOOR AIR (NEAR & MID PLUME APARTMENTS)

DCE_IA = -.0549 + .00705 * DCE_GW

Correlation: r = .95977

DATA THOUGH JAN 1998
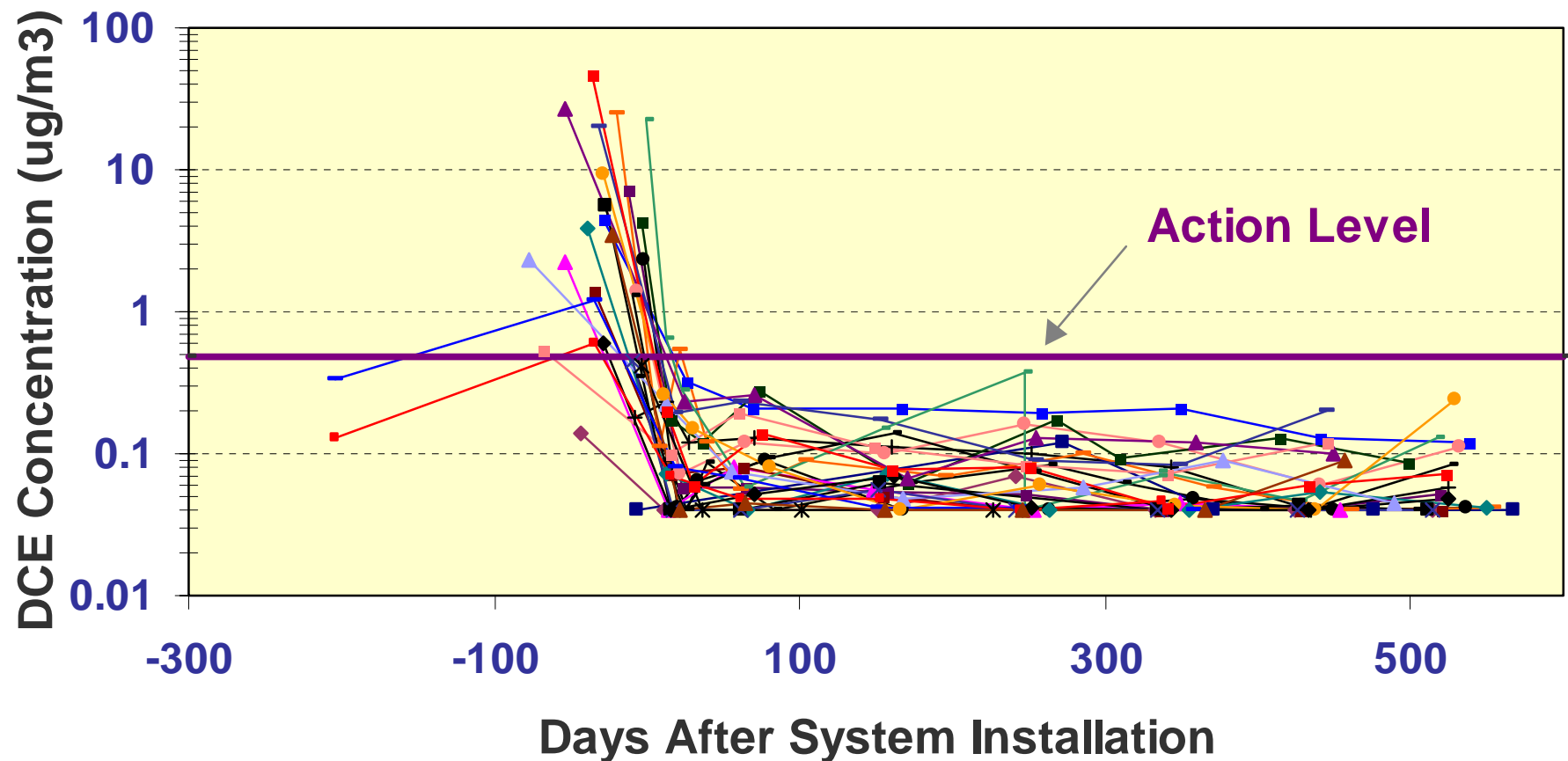
SUB-SLAB SYSTEM PERFORMANCE
(typical system cost = 1 indoor air sample)

Why all the concern with Vapor Intrusion into Indoor Air?

- Risks may exceed those due to exposures traditionally considered in cleanup programs*, such as:

  - Ingestion of contaminated groundwater

  - Ingestion and/or dermal contact with soil

  - For example, even if only* 5 ug/m3 & (MCL 5) ug/l:

  - Magnitude of vapor intrusion exposures are 10 x higher (due to inhalation of 20 m3/day vs <2 l/day)

  - Frequency of vapor intrusion exposures may be >10 x more common (based on few sites to-date)

*(However, may not exceed everyday exposures from "background" concentrations due to everyday activities and consumer products).
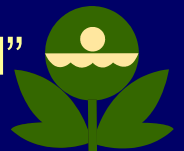
RCRA Corrective Action (CA) Environmental Indicators (EI)

- Environmental Indicators (EI) are how we measure progress (using 2/5/99 Guidance)

- Q3 of EI Guidance asks "_complete pathway_"?

- Indoor air is only 1 of 7 media, & 3/32 of contaminated-media & receptor matrix

- But also; one of the most difficult exposure pathways to be assessed for "_completeness_":
  - Is there a potential problem?
  - Do we need to collect additional data to assess?
  - Do we need to collect indoor air samples?
  - What do the indoor air results mean?
  - _**Is pathway complete in 1 or more buildings?**_

12
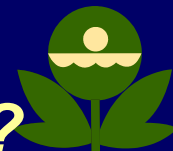
2001 Vapor Intrusion Guidance
(Draft-for-Comment Version (10/23/01))

- Supplemental guidance for Ques. 3 of (2/599) EI Guidance "completeness" matrix
  - Are there concentrations of concern at the body?

- State of the Art/Science (P. Johnson, et. al.)

- EI-like (7Q), flexible, yet scientifically rigorous
  - Highlights latest scientific thinking (...to be proven)
  - Residential-based analysis (open to workers?

- Starting from the outside (source) & working in (towards indoor air) - for many reasons

- Trying to remove as many *sites* as possible
  - as soon as responsibly possible

13

3+ Tiers of screening:

(Draft-for-Comment Version (10/23/01)

- **1-Primary**
  - obvious problem no use studying it too much

- **2-Secondary**
  - empirical observation-based attenuation (alpha)

- **3-Site-Specific**
  - models (such as J&E, with site-measured inputs)

- **+ Cap - Sample indoor air if > 10E6 x target**
  - **if conc. at source is est. > 10E6 x target and you can't find _any_* data to show pathway is not complete; then go inside**
  - ***(including sub-slab vapor samples - best subsurface sample)**

EVALUATING THE VAPOR INTRUSION TO INDOOR AIR PATHWAY

Site Information

Primary Screening

Q1: Are volatile chemicals that can pose a risk (Table 1) present?
Q2: Are Buildings nearby?
Q3: Are Immediate Actions necessary or appropriate?

Immediate Action warranted (Q3 = YES)

Optional Interim Indoor Air Monitoring (Q3 = YES)

Pathway incomplete (Q1=NO or Q2=NO)

Secondary Screening

Q4: Do media concentrations exceed generic criteria (Table 2) with $\alpha=0.01$?
Q5: Do media concentrations exceed scenario - specific criteria (Table 3) for $0.01 < \alpha < 0.0001$?

Insufficient Data

Pathway Incomplete (Q4=NO or Q5=NO)

Yes, and Site-Specific Assessment unlikely to produce a different outcome

Yes, but criteria may be overly conservative

Site-Specific Pathway Assessment

Q6: Do concentrations exceed media-specific criteria developed specifically for this site?

Insufficient Data

Pathway Complete (Q6 = YES)

Pathway Incomplete (Q6 = NO)

Exposure Controls (i.e. avoidance or mechanical systems)

Additional Data Collection (i.e., indoor air sampling, soil gas sampling, etc.)

Incomplete Subsurface Vapor to Indoor Air Pathway

**Q7:** Performance Monitoring or Pathway Monitoring, as needed to confirm evaluation

Q1. Are Volatile Chemicals present that could pose a risk?

- – In groundwater or soil
- – 93 SSL+ chemicals w/ NAPL vapors > risk stds.
- – + = MTBE, Mercury, others ?

- Data needs
  - – Typical characterization should suffice

- Implement-ability
  - – List of chemicals in alphabetical order

- Uncertainties
  - – Generally low, but:
  - – "upper-most" water only - "vapor source term" where vapors are generated (in Appx. A)
  - – probably "upper-most" is proportional to water table fluctuations   (falling is not good)

16

Q2. Are Buildings nearby?

- w/n 100 ft horizontally, of conc. > Table 2 ?
  - Experienced professional judgement based on:
  - potential vapor transport mechanisms
  - typical accuracy of characterization of sources

- Obviously bldg over worst considered first
  - but this allows a boundary for area of concern
  - don't forget to consider vertical decent column
    - Sometimes closer than groundwater

- Data needs
  - Identification of receptor buildings, do-able

- Uncertainties
  - Generally low, but need to have plume defined
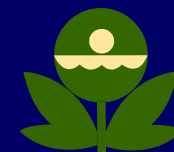
Q3. Are Immediate Actions necessary or appropriate?

- Explosive conditions expected?

- Odors? (thresholds often higher than risk lev.)

- Acute (observable) Effects (on occupants)?

- Vapor source term Inside Bldg (wet) ?
    - Sumps, obvious sewer/utility lines, dirt floors, flagstone?
    - Non-typical building structures or geology ?

- Data needs
    - Understanding of receptors & buildings; do-able?

- Uncertainties
    - Variable; dependant on receptor awareness?

Secondary Screening
(empirical & 'controlled-model' attenuation (alpha))

- Screening Out begins in earnest (via Tiers)
  - Previous only = No volatiles, No buildings
  - *w/o Primary unknown number not screened*

- False Negatives (incorrectly screened out)
  - Are lost from further concern =continued exposure

- False Positives (incorrectly screened in)
  - Are only carried to next tier of analysis
  - May require additional data collection or analysis
  - Unlikely to carried forward to next higher tier, if unnecessary

Q4 - Do media concentrations exceed <u>generic</u> criteria ?

- w/ alpha = 0.01 (no model, **min.** DAF, >Q3)

- Intended to allow rapid screening

- Media = soil gas, groundwater or (indoor air)

- Media-specific targets in Table 2
  - soil gas targets can be under bldg, or >5 ft bgs
  - groundwater targets assume full Henry's Law equilibrium partitioning (at Std. Temp. & Press.)

- Data needs
  - typical characterization data should suffice

- Uncertainty
  - v. low & reduced by multiple lines of evidence/media, e.g., soil-gas depth profiles

Target Risk Levels

- Lower of: (per constituent)
  - **10E-5** incremental lifetime cancer risk [now 10-4 to –6]
  - Hazard Index of **1.0**

- Target risk levels for interim EI assessment (not for long-term cleanup determinations)

- Higher than typical point of departure chosen so that we could (remain true to the science) and screen out some cases from EI priorities

- (i.e., be some what realistic about what we could actually achieve, given the state of the science and resources available)

- Based on 70 yr residential exposure vs 30

Q5 - Do media concentrations exceed <u>scenario-specific</u> criteria ?

- w/ alpha = 0.01 to 0.0001 (two more "orders")

- Alpha based on "controlled" J&E model and:
  - **Depth** to Source (0 to 30 meters)
  - **Soil Type** (SCS; Sand to Loamy Sand) Overall?

- Graphical illustration readily implement-able, transparent, & negotiable

- Media-specific targets in Table 3

- Data needs
  - slightly enhanced characterization should suffice

- Uncertainty
  - low & reduced by multiple lines of evidence/media, e.g., soil gas depth profiles (protective modeling)

Q5 - <u>scenario-specific</u> - Continued

- Protective defaults for "controlled" J&E model
  - between 30-100+ times more protective than web

- Primary differences due to
  - 1) Water-filled porosity-
    - RCRA vary w/ soil type (grain size)
    - RCRA only below bldg matters (1/2 resid. sat. & field cap)
  - 2) Soil-gas advection rate (Qsoil)
    - RCRA fixed at 10 Liters/min. (w/o detailed crack knowledge)
  - 3) Ventilation rate
    - RCRA assumes exchange 1/4 hours (w/o detailed knowledge)

- If conc. > Q5 targets go to Q6, but if >100 x

- + Cap on modeling (source 10E6x indoor std)
  - Collection of more direct evidence appropriate

23

Q6 - Do media concentrations exceed <u>Site-Specific</u> criteria ?

- alpha=0.0001 to 0.000001 (2 more orders)

- Alpha based on "measured inputs" modeling w/ J&E-like model
  - **Use Q5 defaults <u>except where measured</u> value accepted by regulators**
  - **Many <u>important inputs not easily measured</u>**
    - Moisture/air-filled porosity under bldg, Qsoil, bldg exchange rate, capillary fringe conc., height, fluctuations

- Data needs
  - characterization can be significant

- Uncertainty
  - moderate (less protective inputs), accuracy depends more on validity of model structure

Q6 - <u>Site-Specific</u> concerns

- Spreadsheet with J&E-like model using Q5 defaults and "measured inputs" needed
  - w/ forced No output w/o printing all inputs

- And because:

- **Uncertainty** is moderate, or more <u>AND</u>

- **Risks** may be moderate, or more
  - Potentially exposed persons may want to be aware they are being screened out (modeled away - without direct evidence)

- Validity of model structure & predictions should be tested (% on-going Q6-screen outs?)

Q7 - Will performance or pathway monitoring data be collected ?

- Performance monitoring for effectiveness of engineering control systems (e.g., sub-slab)
  - pressure testing, or analytical sampling
  - some fine tuning needed to get 99.95 removal

- Pathway monitoring (in future) maybe needed
  - depending on vapor front arrival & equilibrium conditions (for all constituents)
  - need is decided by lead regulatory authority
  - may be related to the margin of safety from criteria

- Determination sign-off and contact page

Modeling Controversy
## Focused on Johnson & Ettinger "model"

- News media exaggeration of:
  - modeling errors (when used, results, applications)
  - over-simplification of indoor air sample meaning
    - completing ignoring indoor samples starts new study of source

- J&E equation similar to addition model
  - <u>you get out what you put in</u> (inputs matter) [proof]
  - model "results" (w/o all inputs) are meaningless
  - J&E has some construction limitations (screening)
  - <u>inappropriate use not fault of model</u> (too easy?)
  - screening needed, reasonable tool w/ typical data
  - missing data should be replaced with protective defaults (e.g., like those in Q5 & should = SF web)
  - more direct evidence needed to validate prediction

- Prevent adverse health effects = bottom line

- Reduce vapor intrusion exposures, by:
  - considering <u>pathway on par</u> with others (concept)
  - provide practicable guidance that can/will be used
  - national benchmark that is fair, practical, and technically defensible

- Efficiently screens to identify* ***<u>sites</u>**** (to remove as many *<u>sites</u>* as resp possible ASAP
  - have a low false negative rate (at each tier)
  - flexibility to allow but not require higher tier screen
  - allows predictions to be verified and documented
  - <u>provide incentives</u> to protect human health as cost effectively as possible [*Not to delineate prob.]

28
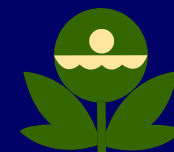
# OSWER Guidance - One Cleanup Program

Special Issues for Risk Assessors

- Objective - Protect <u>populations</u> by:
  - Efficiently screening all potential *sites* to identify problem sites (and to remove as many *sites* as responsibly possible ASAP)

- If pathway "complete"* in <u>1 or more buildings</u>
  - w/ generic exposure scenarios (e.g., R3's RBCs)
  - (It is <u>not</u> appropriate to vary exposure factors here)
  - <u>Full delineation of affected bldgs needed</u>
    - Delineation methods to be added to guidance (when ?)
  - Variation in exposure factors should be bldg-specific and only with notification of occupants
    - for RCRA EI detailed exposure analysis (i.e. variations in exposure factors) are to be documented on 2/5/99 forms (Questions 4 and/or 5)

Summary of proposed edits
for OSWER-wide One Cleanup Program

- <u>Evaluating the Subsurface Vapor Intrusion Pathway: Interim Guidance for Cleanup Programs</u>

- Exclusionary Criteria (Q4a, Q5a)
  - preventing application of generic modeling
  - pushes those sites to Question Q6
  - may allow re-calculation of Q5 graphs
  - considering treating gw & soil-gas separately in Q5

- Question 6 now recommends Sampling:
  - Sub-slab, Crawlspace (1/1), Indoor Air *
    *(then distinguish subsurface from indoor sources)
  - From representative number bldg / plume area

- Several major issues remain to be decided:
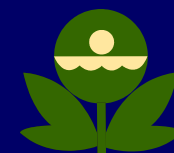
#1 Critical Policy Issue
Identification of Problem < MDL/MCL ?

- Theoretical concerns for potential risks with:
  - Groundwater (soil-gas, or air) concentrations:
    - < Max. Conc. Limit (MCL)   [so are RBCs]   (current)
    - < Min. Detection/Quant. Limit (MDL/QL)   (current)

- Field evidence of problems <MCL very limited
  - appearances may be explainable via preferential pathways from higher-level sources (see Redfld)

- Very difficult to justify new groundwater characterization as necessary at this time to **identify new problem areas** (I.e., no portion of the problem above the approp. Level (e.g., MCL)).

- Evidence from the Delineation of the extent of **identified problems** (not part of this guidance, yet) will establish this.

- Proposal = Use current plume delineation*
  - ***Except where non (>>) drinking water "stds" were used**

#1 Critical Policy Issue (cont.)
Identification of Problem < MDL/MCL ?

Proposal = Use current plume delineation*

- To identify problems
- *Except where non- (>>) drinking water "stds" were used

- **Implementation choices & implications**

- **Leave _theoretical_ (MCLG-like) values in guidance**

  – **Implement as possible and let science show reality**

- **Or**

- **Place _higher of_ current values in tables**

  – **Which may set precedent for (a higher) risk level of concern for this pathway**

  – **(based on technology Not designed for this pathway)**

#2 Critical Policy Issue
"Background" Concentrations

Man-made "background" sources:

– **Outdoor (Ambient) Air**:
- Numerous stationary and mobile sources of air toxics
- <u>Enormous Agency effort to reduce air toxics loading</u>
  – Some outdoor contaminants from same facility as gw plume
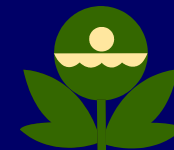
– **Indoor Air**:
- Numerous indoor consumer-product sources of air toxics
- <u>Significant Agency effort to reduce air toxic in indoor air (biggest risk)</u>
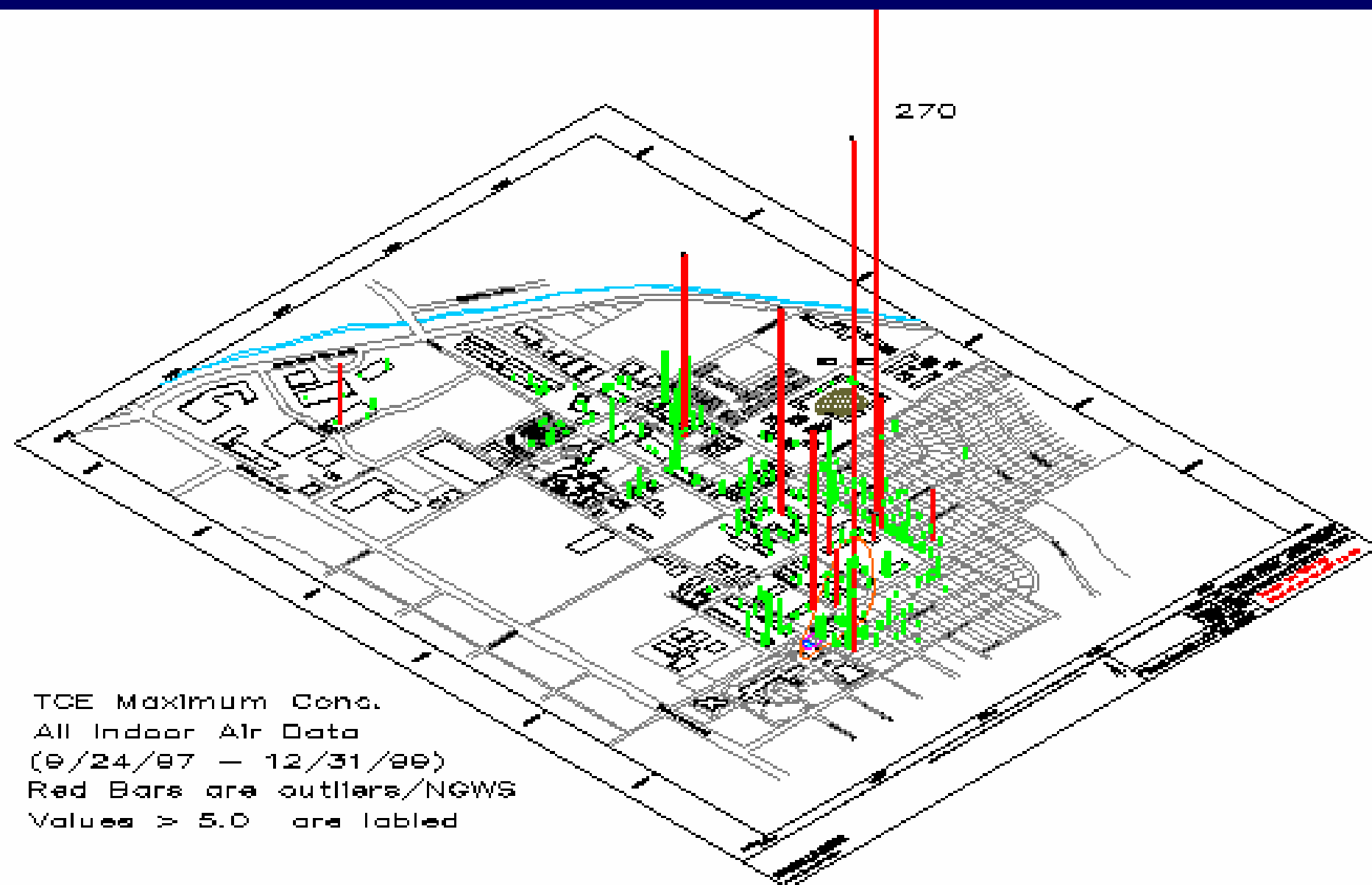 – Contribution from tap water supply at MCL (2x) ?

– **Other** lifestyle / activity / short-term exposures:
- Numerous workplace exposures (with much higher levels)
- Numerous hobby & maintenance (e.g., painting, lawn mowing) activities, visiting dry-cleaners, pumping gas, finger nail polish
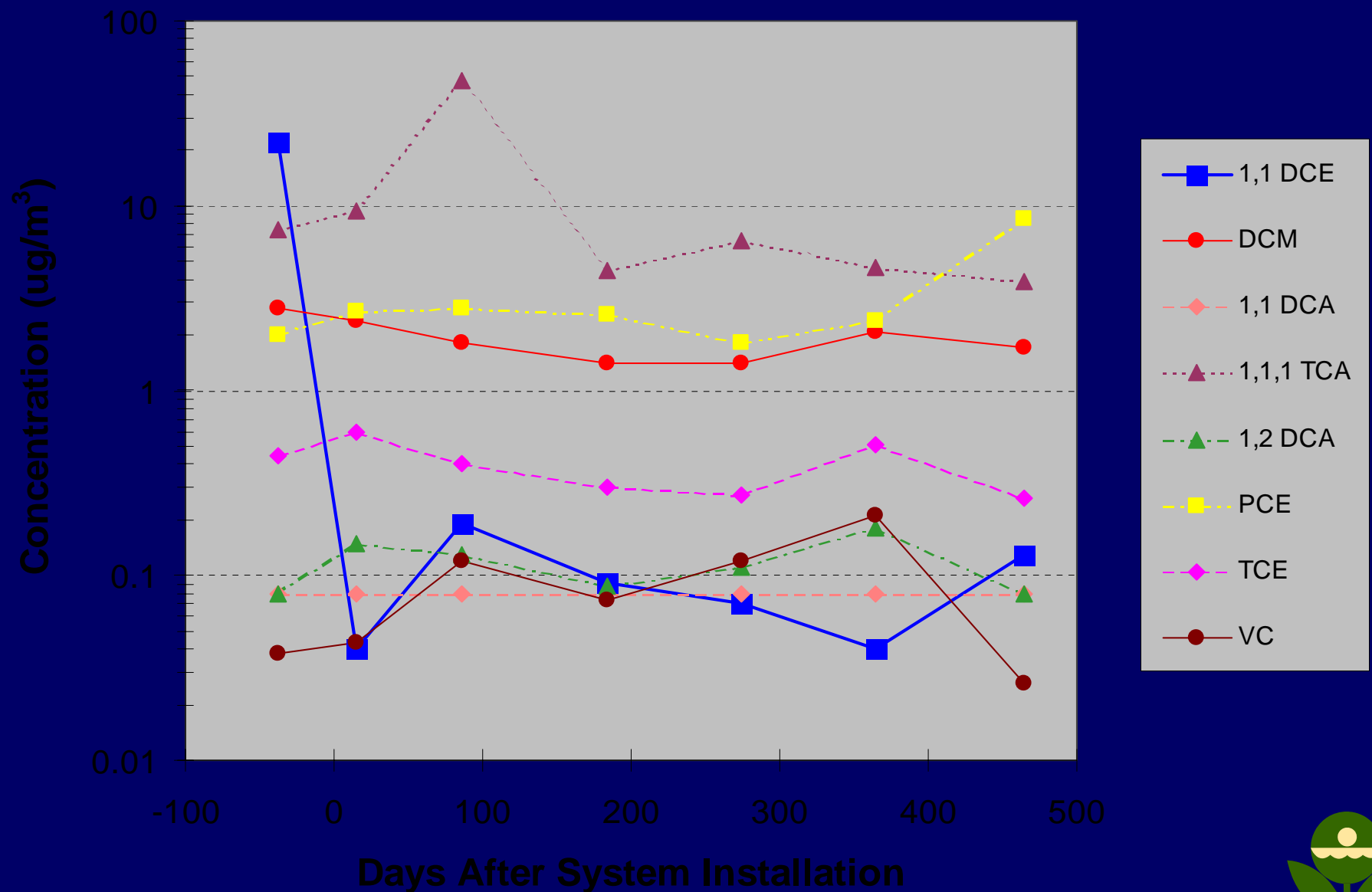
- **Only an issue <u>if</u> sampling indoor air**
  – Technically, only important if sampling indoor air

270

TCE Maximum Conc.
All Indoor Air Data
(9/24/97 — 12/31/98)
Red Bars are outliers/NGWS
Values > 5.0 are labled

34

BACKGROUND VOC LEVELS IN MITIGATED HOMES

What is an acceptable level of (additional) risk for VOC exposures from soil gas?

- Should we accept <u>HIGHER</u> risk levels for indoor air exposures (from soil-gas sources) [than from soil or groundwater exposures]?

- Or, <u>LOWER</u> than normal risk levels?

- Both? Or Which? Because:
  - **many receptors are already exposed** to significant levels in indoor air (and other personal exposures)

- What would the exposed public think?

- Human body integrates all sources (limits?)

- **Background = <u>moving up dose-response curve</u>**

- Slide from Aug. 15, 2000 EI Forum 7pm presentation

Comparison of Personal and Subsurface Exposures

(Position 1 - "Should not significantly increase")

- Direct comparison - (adding) - assumes risks are **the** same

- However, the exposures and risks are different, e.g.,:

Personal VOC Pollution	SubsurfaceVOC Vapor Intrusion
Voluntary	Involuntary (& unavoidable)
Awareness	No awareness
Implicit acceptance	No permission
Assumed benefits	No benefits
Personally controllable	Not readily controllable
Personally responsible	Not responsible

- All important in the definition of "**acceptable**" risks

Man-made "Background"(cont.)

Our responsibility is only regulated (sub-surface*) contribution

? Only concerned if >"background" level (>2x) ?

- **Wrong in CERCLA Background Policies 5/1/02 & Soil**
  - Carry through Risk Characterization
  - Important Risk Communication responsibility
  - HJS interpretation: "Do not screen out before you start"
- Literature # - Going down, Avg. w/ Outliers, Fair?
- Only an issue, technically, if sampling indoor air

- **Incremental risk policy**
  - <u>doesn't raise or lower</u> acceptable limits based on pre-existing "background" **<u>risk</u>** levels
  - <u>Incremental risk policy is an intermediate position</u>

  - Also allows these exposures to be treated similarly to soil and groundwater

Petroleum/Biodegradable Constit.
(What is the best way to handle them?)

Biodegradation is well documented, but here?

Prediction of biodegradation is not ready yet

Don't want to waste a lot of unnecessary time on sites that don't present real risks (while others do)

Don't want to unnecessarily raise concerns, via:

In-depth investigations due to "false-positives'

Publication of theoretical gw risk values that never occur (<u>poor correlation</u> of gw to IAQ)

Proposals – Cut Out, Mass flux, RBCA, 10x*, SG

*Unless conditions likely to prevent bio-degradation

Non-residential exposures
(What is the best way to handle them?)

- Environmental vs Workplace exposures
  - 1+hr. Session on www.clu-in.org/EIVapor2002

- Occupational Exposure Levels "incompatible"
  - Documented rates of disease assoc. w/ OEL
  - Role of awareness & acceptance of de-minimus incremental risks needs to be considered carefully
  - Particularly for workers with similarly toxic exposures who are notified (and aware) of incremental subsurface contributions (laughable?)

- Proposals -Dur., Bldg Vol., ER, OELs (1/x?), Notification
  - OELs could become basis for cleanup numbers
  - Notification could achieve protection w/o reference to OELs or jurisdictional debates

40