Introduction & Background

for

USEPA VI Workshop at AEHS WC Conf.

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More Cost-Effective Vapor Intrusion (VI) Cleanup & Exposure Protection Strategies?

Henry Schuver, DrPH, MS geology

USEPA, OLEM, ORCR, PIID, CPB

Washington, DC

Schuver.henry@epa.gov

w/ Drs. Crincoli, Lutes, Holton, Stewart, Schumacher, Zimmerman, Williams, Abreu & Lee

As you know, We've spent Decades …

- Building, interpreting & evaluating Vapor Intrusion ***data sets***, for:
  - Model predictions
  - A few 'random' grab/24-hr indoor air samples
  - Continuous indoor air samples over months to years
- But the challenge to address VI exposures **cost-effectively** remains largely **un-met**:
  - Typical 'reasonably affordable' methods are now known to be *in*-effective, &
  - Fully-effective methods, e.g., cont. monitoring ea. Bldg. are cost* prohibitive
    - & 'smartly' timed indoor air samples are improving, but still short of 95% Confidence of GW_{ing}
  - **We could use a more practical and cost-effective approach** for VI problem

*Financially & Socially
(indoor access to sample & acceptability of bldg.-specific mitigation 'bringing' contamination towards their bldg.)

Today *you** will get to choose Alternate project management Strategies in Simulations

- That is:
- We will *all* see the **Costs** and **Effectiveness** of your chosen;
  - **VI Site Investigation & Mitigation/Remediation** project management **Strategies**
- In Simulation(s) using real evidence from field-measured Data-Rich Case Studies
- In summary, the VI cleanup and exposure prevention provided / $$
- This is a developing simulation tool & we hope to have multiple runs today

Introduction

- EPA partners with other federal agencies, states, tribes, local governments, and communities to meet its **core mission of cleaning up legacy contamination** and revitalize land for reuse.*

- Chlorinated solvents, such as PCE, TCE, DCE & VC (sometimes called **C**hlorinated **V**olatile **O**rganic **C**ontaminants (**CVOC**s)) can be some of the **most common legacy contamination** at many of our cleanup facilities/sites.

- Spills of **chlorinated solvents commonly form long-lasting plumes of contaminated groundwater**, much of which is now off the site of release and flowing under communities.

* ~OLEM section of *Project 2025* document

These CVOC-contaminated GW plumes have caused *unacceptable* exposures in the past

- Unknowingly, or unavoidably, many communities **ingested/drank CVOC contaminated** groundwater (GW) from private or public water supplies *pulling* contaminated water into their **well's 'capture zone'**
  - Community **health studies** of those areas showed **elevated Disease rates**, and significant medical & lost-work cost burdens.
- Water **exposures** were successfully **controlled decades ago**, because:
- **GW** Cleanup & Exposure prevention management **strategies** had **Evolved** to;
  - **Cost-effectively** & successfully **prevent all* drinking exposures**, while **cleanups continue**

How did contaminated $GW_{ingestion}$ Cleanup & Exposure Prevention Strategies Evolve?

- Four (general) stages:*
  1) Initial recognition of concern for exposures (1950-70s)
  2) Early approach to assessment (1980s)
     Tap/sink-water samples to confirm *building-specific* ***exposure pathway***)
  3) Experience-based approach: (1990s-)
     Assess areas Contamination in **environmental media** (GW) & use
     Physical controls to **prevent** a Complete pathway for ***unacceptable*** **Exposures**
  4) Observations (& Comparisons) of Community Health/Disease rates
     - Before &
     - After stopping (ingestion) exposures**
- The cost-benefit of contaminated GW_{ing} cleanups are documented

*personal perspective

**some cases where elevated disease rates continued (VI?)

But we have a Two Plume problem

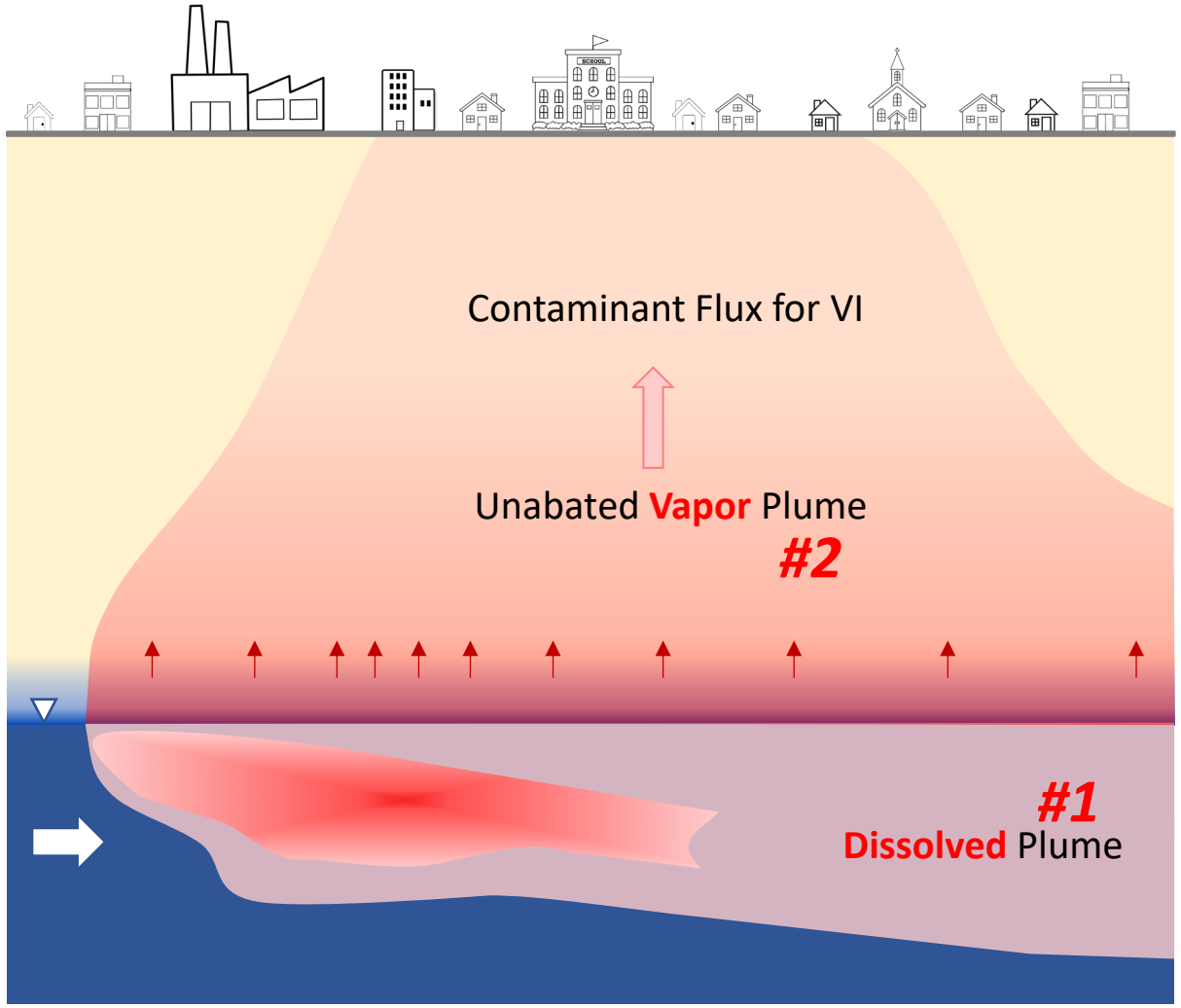
- With CVOC contamination both *in* and *from* the GW media
  - Plume 1 – has CVOC contamination ***in*** the GW media
  - Plume 2 – Is the CVOC contamination ***from*** the contaminated GW media

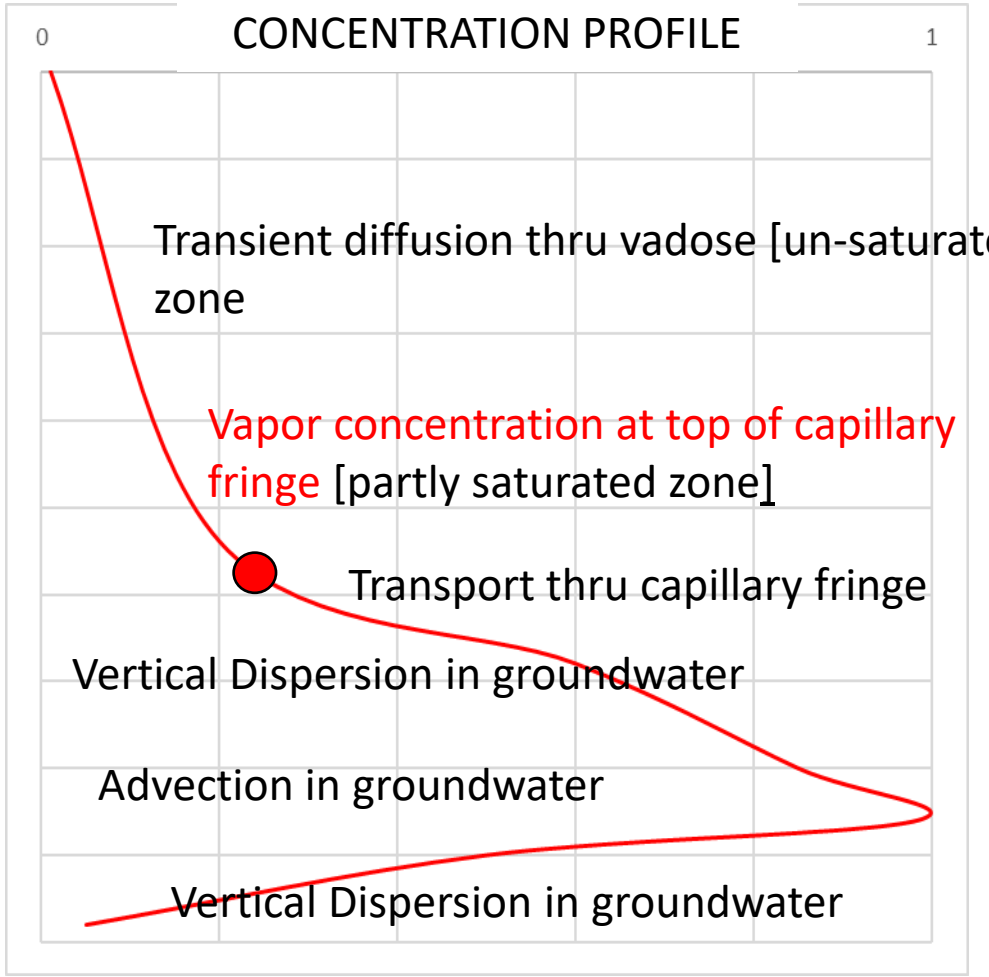
- **Plume 1 problem**:
  - CVOC contaminated **GW ingestion** exposures is **~Solved** ✓

- While GW plumes are being cleaned up, they are *mostly* still there

- **Plume 2 problem**:
  - Volatile (vapor-forming) Organic Contaminants are entering the soil gas and indoor air of **occupied** buildings/structures above
  - Groundwater sourced Vapor Intrusion (**GW_{VI}**)

Conceptual Model for Upward Mass Flux from Contaminated Groundwater - *TWO Plumes*





[Figure by Bo Stewart, PhD, *modified by inserted text is italicized for this Introduction]*

The Cost-effective and Successful Strategies for Contaminated $GW_{ingestion}$ risks *involved*:

Environmental Monitoring to:

1) Define the **Nature & Extent** of the contaminated GW plume
2) **On-going** GW **Monitoring** to verify the Remedy/Cleanup can show:
   - **Control** so contamination plume is **Not Expanding** – causing increasing or new risks
     - &
   - **Keeping** contaminated **plume away from** water-supply **well capture zones**
     - And/Or as needed, point-of-use treatments or
       - Allowing some controlled blending of wells **w/ thorough monitoring** of water supplies by "**R**Ps"
   - All while **Cleanup** of Contamination (*dissolved*) in GW **is continuing & progressing**

- Thus, meeting our core Mission **Protect Human Health & Environment** by:
  - Providing **Clean** drinking **Water for Every American**

Some **Background** for EPA's 2025 Vapor Intrusion (VI) Workshop

- A **Comparison** of **Project Management Strategies** for Cleanup and Prevention of 'complete' and unacceptable Exposures via:
  - Groundwater (**GW_{ing}**) ingestion
  - Vapor *(from* GW*)* Intrusion (**GW_{VI}**) inhalation
- In Summary:
- **GW_{ing}** Cleanup & Exposure prevention has evolved to a **highly effective**
  - Clearly & successfully preventing ~all* exposures, while cleanups continue
- **GW_{VI}** Cleanup & Exposure prevention remains **largely *in*effective***
  - Typical methods are 'expensive' & have confidence levels ~ the 'flip of a coin'

* Personal perspective

I recall, we spent ~5 yrs modeling* & 25 yrs 'grab' sampling vapor indoors (at convenient/random times), i.e., sampling indoor air **for VI**:

- Inside **highly variable Human Built indoor environments**, i.e.,
  - After interaction with
  - Near-surface excavations, sewer & utility conduits/piping Bldg. excavations/in-fill material under buildings with known variability in:
    - Basement/foundation (& whole building)
    - Design
    - Construction
    - Condition/Age
    - Modifications
    - Operations
    - 'Representative' Rooms at the Exposure Point (Bldg.-specific)
    - Climate/weather zone
    - Orientation to (sun & wind), Topography, vegetation, etc. …

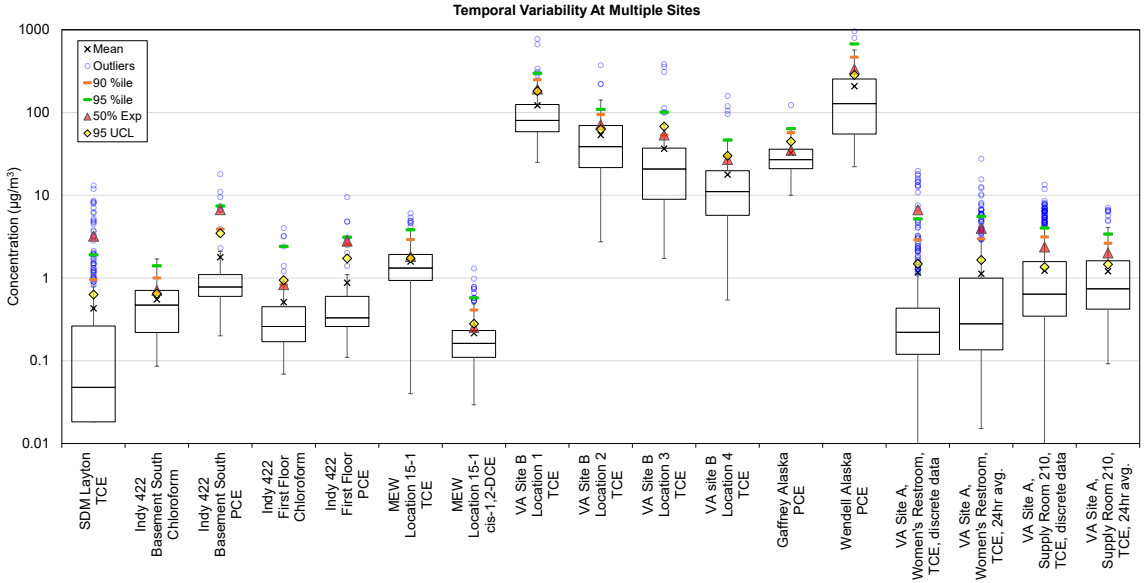
This is the zone of:
Un-natural attenuation
Not predictable**

*for model results that could *not* be validated (unless we called silty-clay with some desiccation cracks, a sand (because it 'behaved like a sand') at CDOT site Colo.

**In my opinion

Now after ~10 yrs of long-term ~**continuous** sampling indoor air in ~dozen bldgs., we find:

- It appears that indoor air VI conc. are **commonly so variable** on short-time frames, that relatively **rare** and unpredictably **episodic peaks** with conc. 1-3 OoM > baseline;
- Can **largely determine** both
  - **Short-term** and
  - **Long-term** (annual average)
- **Exposures and risks**

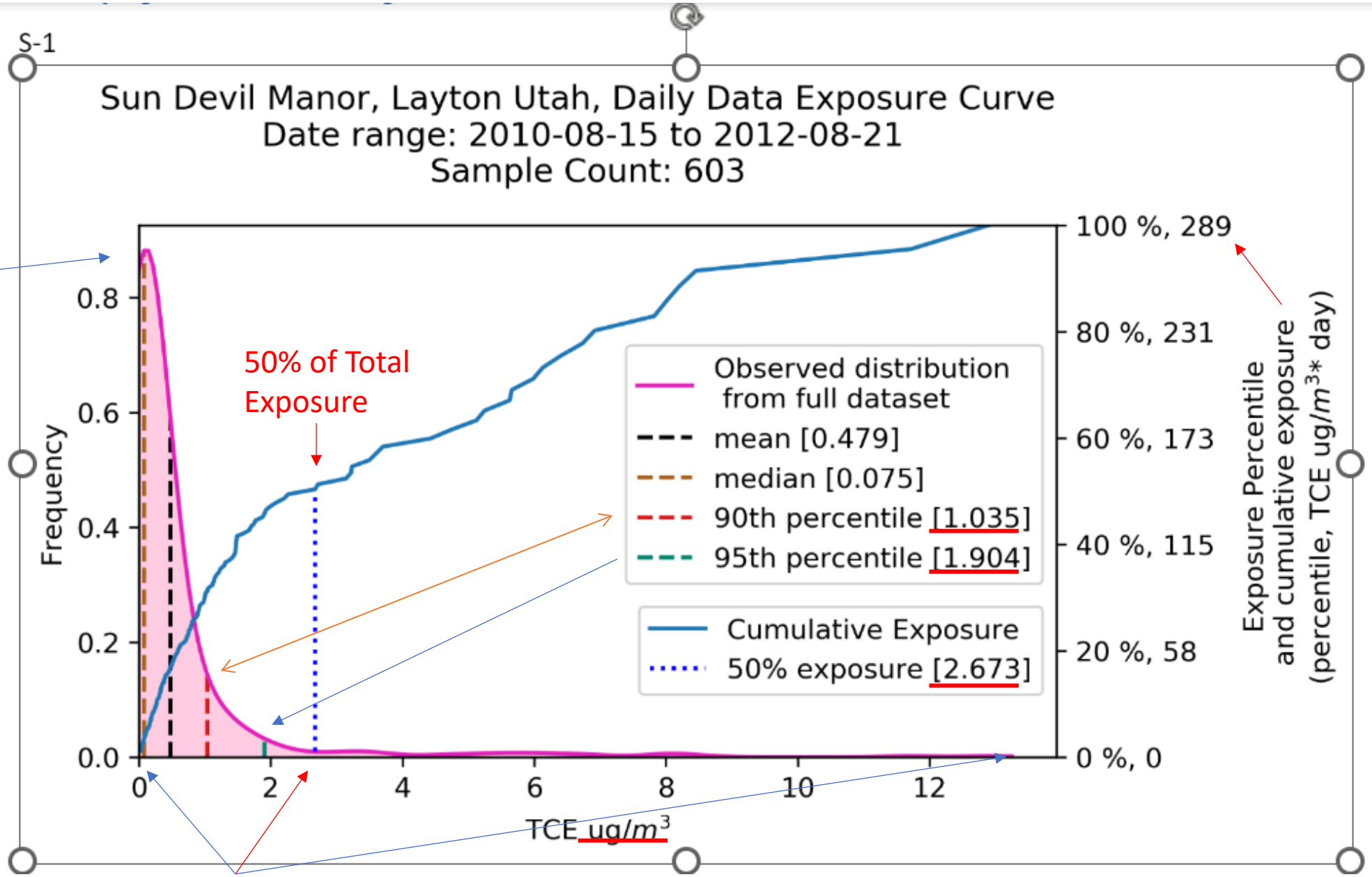


2 Years of ~**Continuous** Monitoring; Data ref. Holton et al., ES&T, 2013, 47, 13347-13354

Fraction of **Freq.** of **Data & Time**

(for equal timed samples, shows)

~85% of **data/time** with **~~ 0 Conc.** & ~~0 total **Exposure**



If you sampled all conc. up to **95th** %ile **Conc.** it would Only represent **~40%** of Exposure

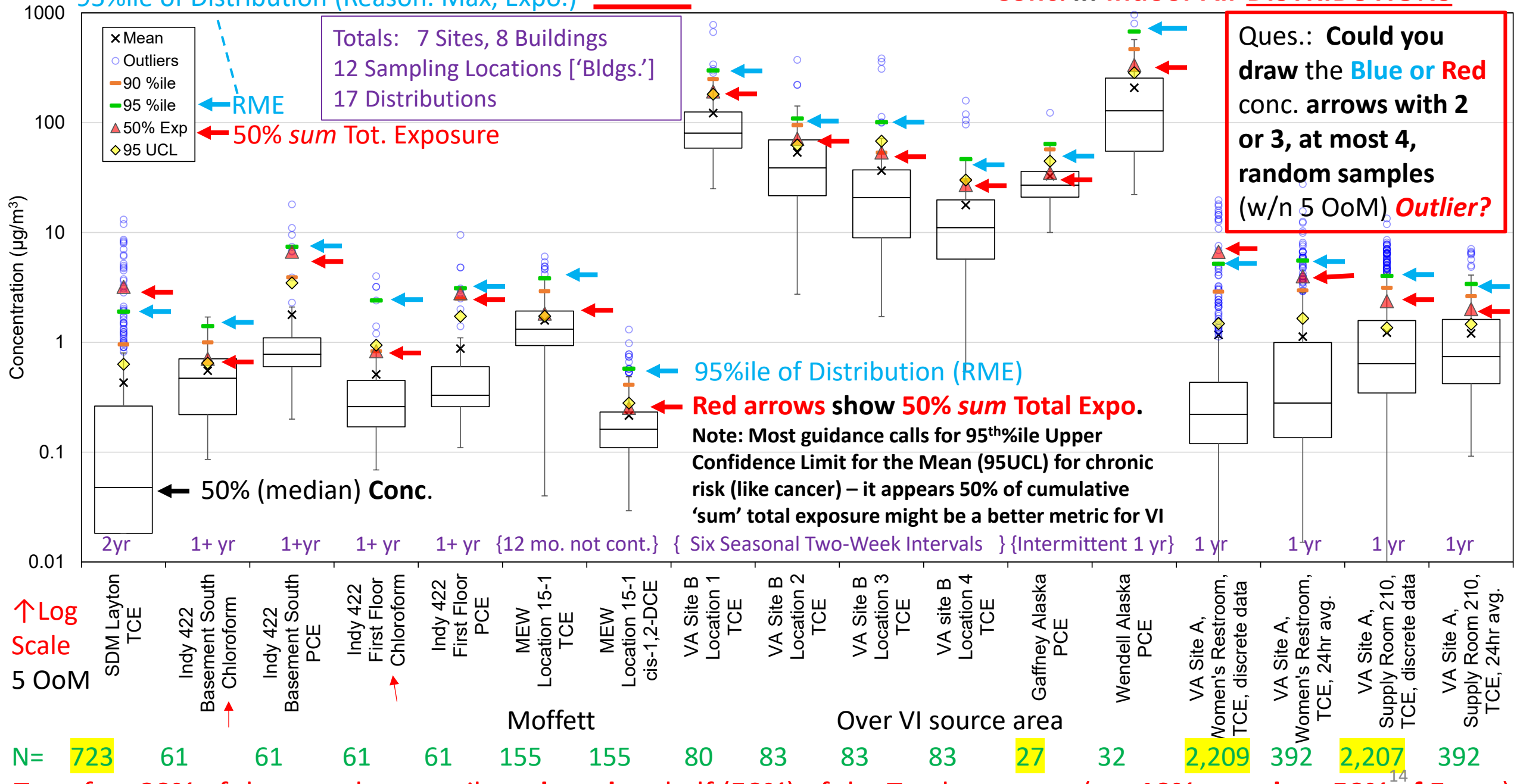
Highest 5% of data; **Conc. 95-100th%ile** represent **~60%** of Exposure

50% of total exposure from 3.5% of the 2-yr time/samples (w/ conc. >2.673 ug/m3)

Conc. *in* Indoor Air DISTRIBUTIONS

Temporal Variability At Multiple Sites

95%ile of Distribution (Reason. Max, Expo.)



Too often **90%** of the samples contribute **less than** half (**50%**) of the Total exposure (~~**<10% samples >50% of Expo.**)

List of diseases assoc. w/ CVOCs is growing

- For example, TCE & **Parkinson's Disease** (PD)*
  - The number of people with Parkinson's disease (PD) has more than **doubled in the past 30** years and, absent change, will **double again by 2040**
- A literature review (including 7 **TCE case studies** involving 8 individuals, **epidemiological studies** of **workers/hobbyist using TCE**, and soldiers at **Camp Lejeune**, NC) indicates;
  - Environmental contamination "is contributing to the **global rise of PD** and that **TCE** is one of its invisible and **highly preventable causes**."
- "**We** conclude with a **call for greater** research on its effects on PD, **protection from and remediation of contaminated sites**, and banning of this century-old chemical that has caused immeasurable harm to the public's health."

*Dorsey et al. Journal of **Parkinson's Disease** 13 (2023) 203–218

12 Physicians urging us to do our Cleanups*

- **Recommendation** "2. Clean and contain contaminated sites – Hundreds of thousands of sites are contaminated across the U.S. and globally. They are found in strip malls where dry cleaners used to operate, on military bases where use was widespread, in cities near old manufacturing sites (especially those near rivers or streams), and in rural areas where landfills were created to dump hazardous waste. Fortunately, contaminated sites can be remediated, and homes, schools, and workplaces can be protected by vapor intrusion mitigation systems like those used for radon. Until they are cleaned, existing contaminated **sites must be contained**, **limiting exposure for humans** and nature. Local, regional, and national authorities should take responsibility in overseeing **rapid control** of contaminated sites."
  - "route of exposure to TCE and other volatile chemicals was recognized: **vapor intrusion**"

*Dorsey et al. Journal of **Parkinson's Disease** 13 (2023) 203–218

Today **You** will get to simulate alternate futures to see the Cost-Effectiveness possible

- With limited computer simulation time,
- We hope we get to explore your most interesting VI protection strategies
- Thank You