U.S. DEPARTMENT OF ENERGY | Legacy Management

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Post-Remedy Vapor Intrusion Evaluation for the Laboratory for Energy-Related Health Research (LEHR) Superfund Site

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Session 4.3: Emerging Issues with Vapor Intrusion

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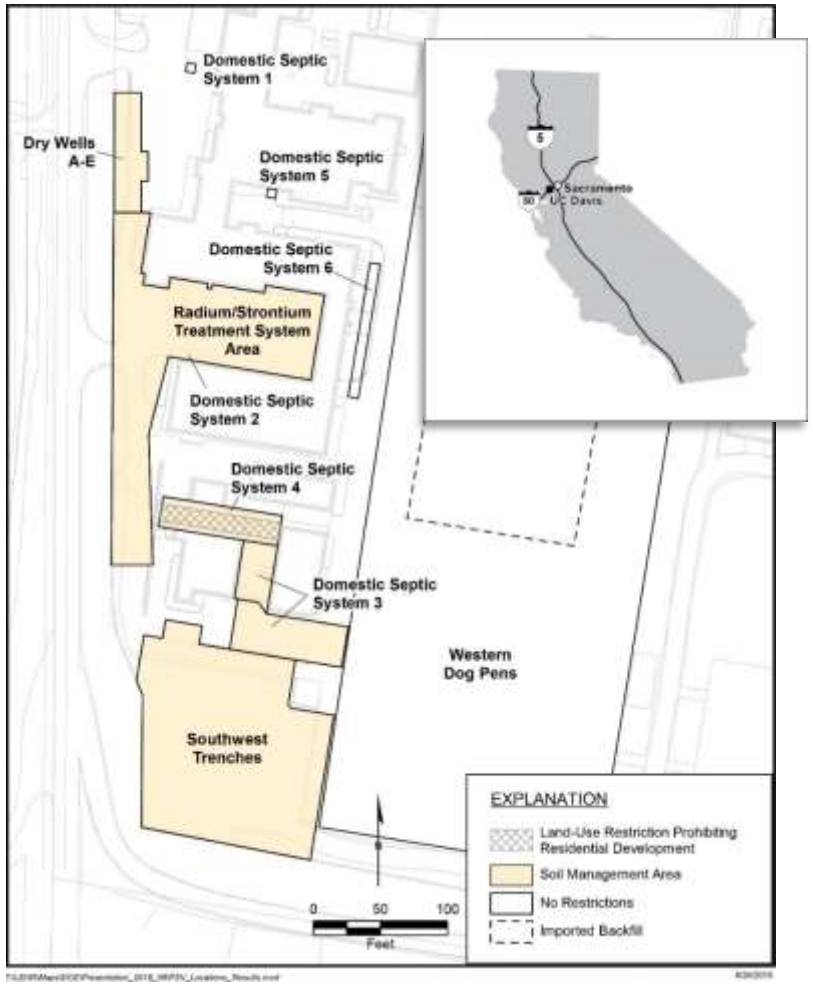
LEHR Site Overview

- 1958-88: University of California-Davis (UC-Davis) studies health effects associated with chronic exposure to low levels of ionizing radiation
- 1994: Site listed on National Priorities List; DOE is designated lead agency
- 2002: DOE completes removal actions to address radionuclides and pesticides in soil; no groundwater impacts
- 2009: DOE issues ROD requiring land use restrictions and ground-water monitoring
- 2011: DOE implements remedy
- 2016: DOE completes First Five-Year Review

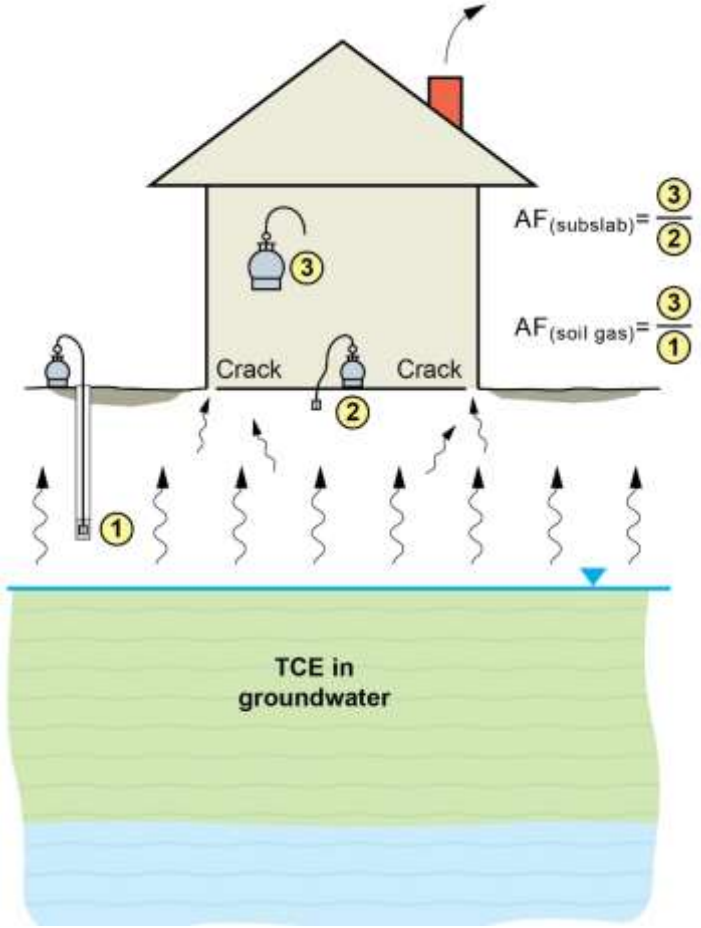


First Five-Year Review Findings

- Remedy protectiveness confirmed for all pathways except vapor intrusion (VI) due to insufficient evaluation during the remedial investigation (RI); no soil gas samples were collected
- Post-removal action soil sampling results showed low-to-trace concentrations of potential vapor-forming chemicals (VFCs) including VOCs, certain pesticides, polychlorinated biphenyls (PCBs), other semi-volatile organic compounds (SVOCs), aldehydes, and ammonia
- To confirm protectiveness of the remedy, U.S. Environmental Protection Agency (EPA) and state agencies requested a VI evaluation of VOCs and lower volatility vapor-forming chemicals (LVVFCs) based on recommendations in OSWER Publication 9200.2-154* and recent California guidelines

** OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*, June 2015 (OSWER 2015)

EPA Evolving Approach to VI Evaluation Database and Default Attenuation Factor (AF)*



- Paired data from sites across U.S.
- Mostly residences with trichloroethene in shallow groundwater as source
- Mostly sub-slab (2) and indoor air (3) data pairs
  - 95th percentile of 0.03 chosen as default AF
- Fewer exterior soil gas (1) and indoor air (3) data pairs
  - More variability in AF than sub-slab
  - Concluded much of soil gas data, not representative
  - Recommended using 0.03 AF for "near-source" soil gas

**EPA's Vapor Intrusion Database: Evaluation and Characterization of Attenuation Factors for Chlorinated Volatile Organic Compounds and Residential Buildings*, March 2012

EPA Evolving Approach to VI Evaluation – Key Tools

- Office of Solid Waste and Emergency Response (OSWER) guidance for assessment and mitigation (2015):
  - Defines "vapor-forming chemical" (VFC) as one with:
    - Vapor pressure >1 mmHg or Henry's law constant >10-5 atm-m3/mol, and
    - Sufficient toxicity
  - Recommends 0.03 sub-slab/soil gas to indoor air AF as default for all VFCs
- Vapor Intrusion Screening Level (VISL) calculator:
  - Issued in 2015 in conjunction with OSWER guidance
  - Calculates screening levels and risks using 0.03 AF
  - May 2018 update includes soil gas residential risk VISL table for all VFCs
- Johnson & Ettinger (J&E) Model:
  - Well-established vapor intrusion model developed in 1991
  - EPA Version 6.0 issued September 2017
  - Generally results in greater soil gas to indoor air attenuation than VISL
  - EPA Region 9: "J&E model should not be used to contraindicate VI potential when VISLs exceeded"

EPA Evolving Approach to VI Evaluation – LVVOCs

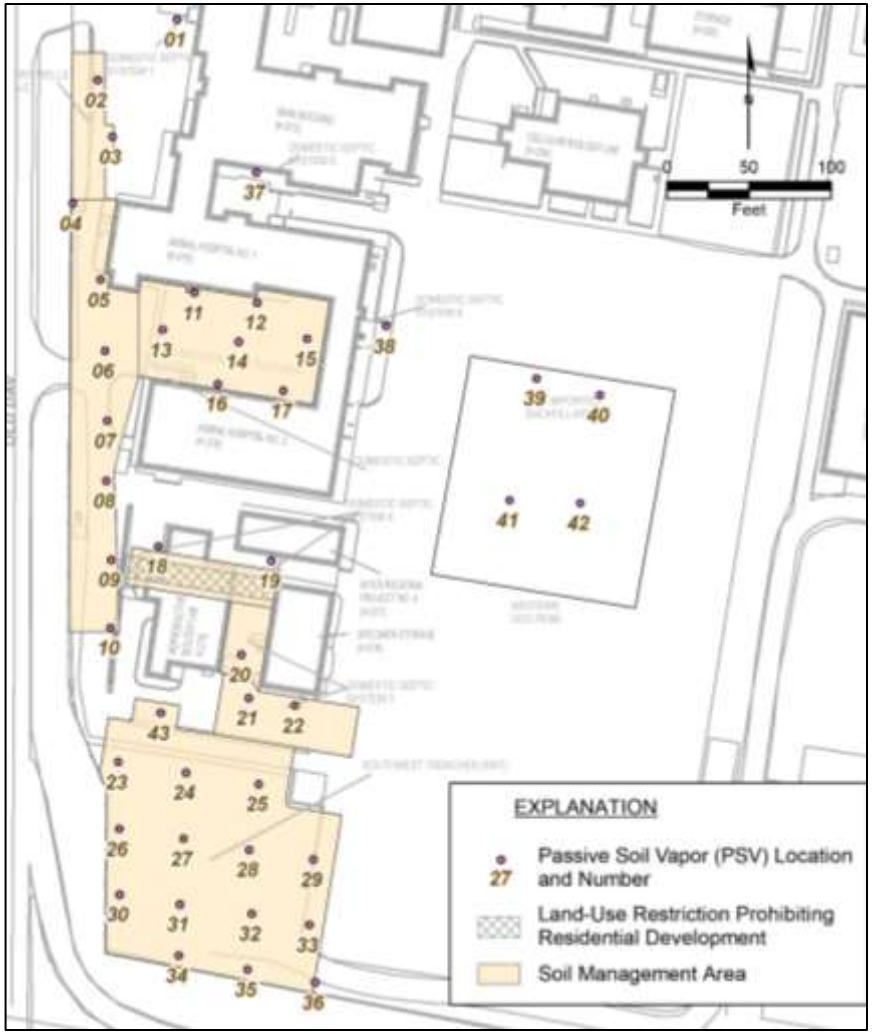
- EPA Region 9 requiring VI evaluation for LVVFCs known or suspected to have been released
- Currently requiring use of 0.03 AF as starting point for risk calculations for all VFCs, although AF is based on paired VOC data
- Higher toxicity of some LVVFCs coupled with assumption of limited attenuation presents significant sampling and analytic challenges
  - EXAMPLE:

Constituent	Indoor Air RSL (µg/m³)	Soil Gas VISL (µg/m³)	Typical Soil Gas Reporting Limit (µg/m³)
Benzo(a)-anthracene	0.017	0.56	170

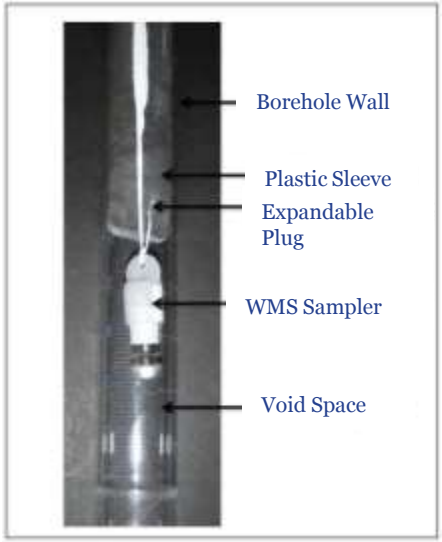
VI Challenges at LEHR

- Selecting and limiting the number of soil gas well locations for VOCs and LVVFCs given lack of obvious sources or “hot spots”
- Standard soil gas sampling methods not developed to meet low risk-based reporting limits for more-toxic pesticides, PCBs, and other SVOCs
- EPA/California EPA requirement to use VOC-based 0.03 soil gas-to-indoor air AF for all LVVFC risk calculations

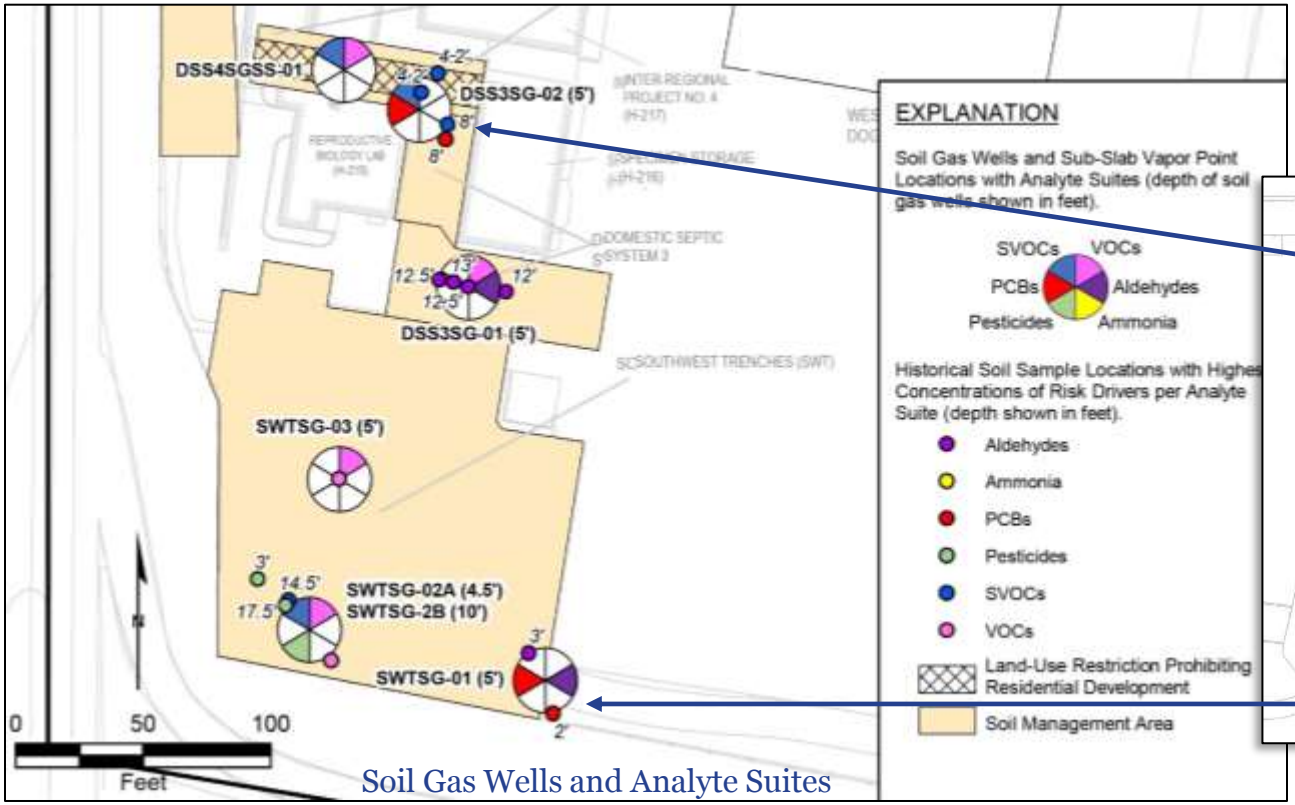
Challenge One: Limiting the Sampling Points (VOCs)



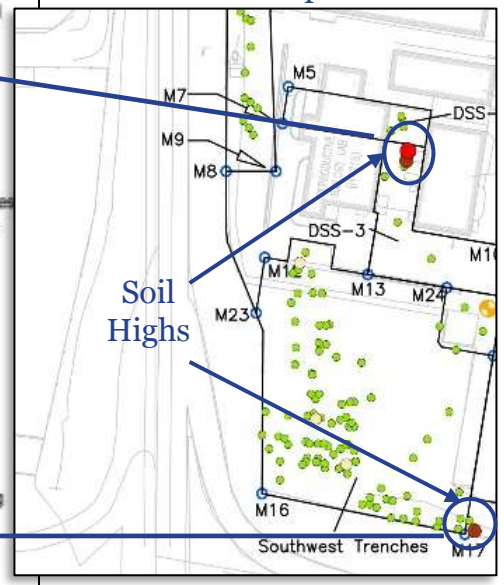
- Started with low-cost passive sampling grid across site
- Waterloo Membrane Samplers (WMS) provide semi-quantitative results proven to correlate well with active soil gas
- Results used to limit active soil gas wells for VOCs to 8 locations



Challenge One: Limiting the Sampling Points (LVVFCs)



Soil PCBs Relative Risk Map



Soil Highs

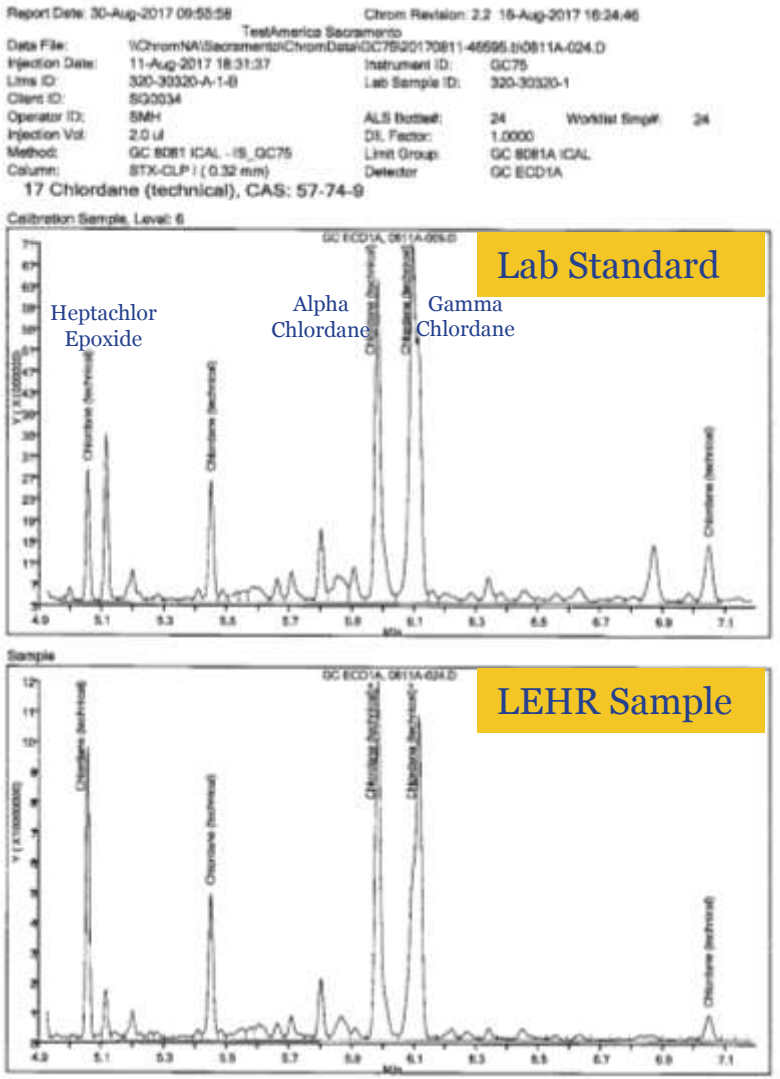
- Physicochemical properties, toxicities, and soil concentrations used to estimate VI risk per analyte suite, which was the basis for soil gas well location selection
- Locations optimized to target multiple analyte suites when possible

Challenge Two: Lack of Suitable Sampling/Analytic Methods (LVVFCs)

- Samples collected by drawing soil gas through analysis-specific sorbent tubes
- Sorbed mass measured in lab and concentration calculated from pumped volume
- Very low soil gas risk-based screening levels meant much larger volumes than typical for soil gas tubes
- Customized sample train and methods developed

Challenge Two: Lack of Suitable Sampling/Analytic Methods (LVVFCs)

- Problem:
  - Chlordane is complex mixture of varying composition
  - Toxicology studies and lab quantification based on specific compositions
  - Difficult to obtain sufficiently low detection limits in lab
- Solution:
  - Worked with lab to concentrate sample and expand calibration range
  - Compared results with those for individual components

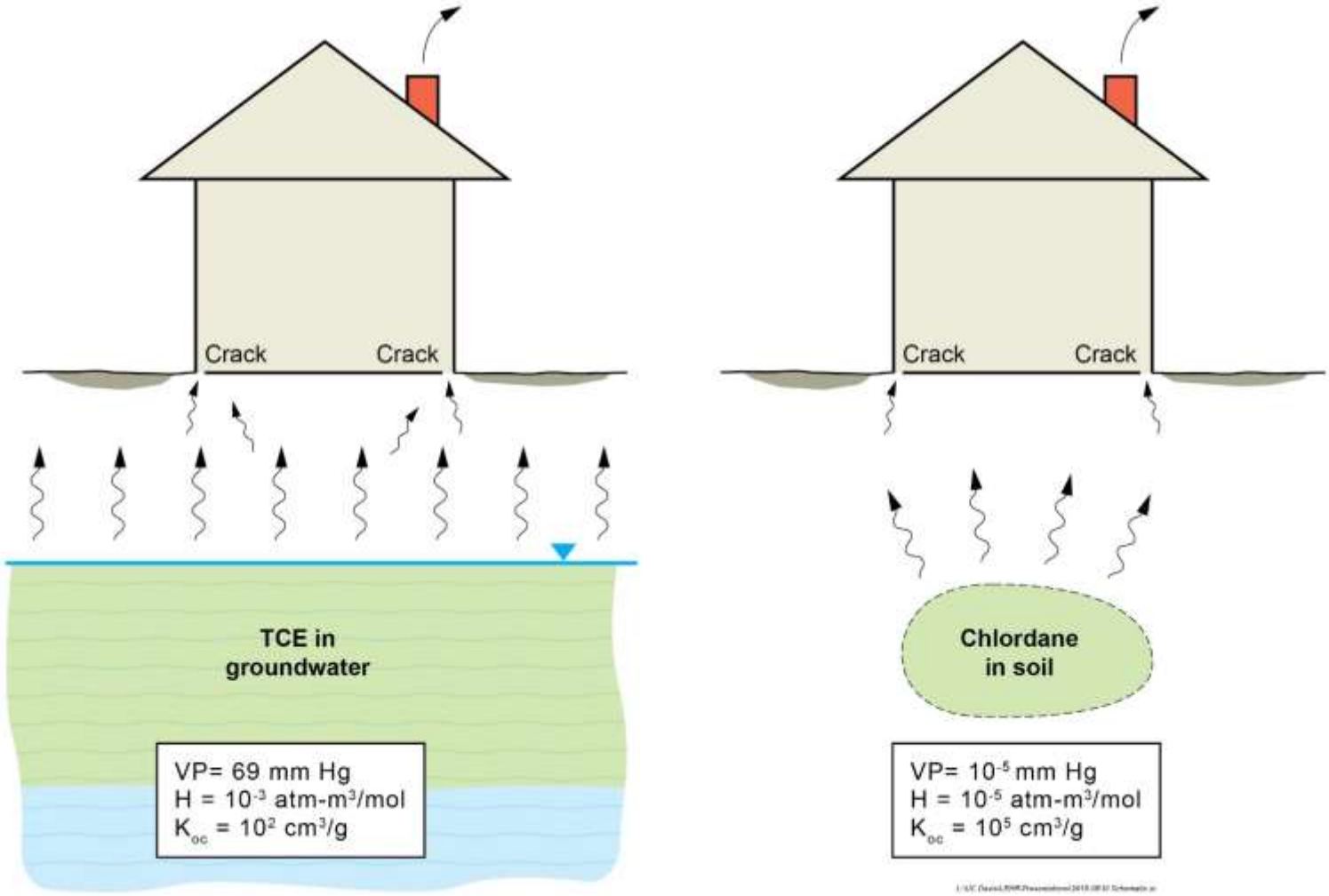


Challenge Three: Demonstrating Acceptable Risk Where Screening Risk Exceeded 10^{-6}*

Factor	Risk Characterization Conclusions
Use of 0.03 AF for pesticides	Probably overestimates risk because physicochemical properties of pesticides likely impede their transport in soil gas when compared with the VOCs from which the AF was empirically derived
Data reliability	Uncertainty in the composition of chlordane in the samples, in the laboratory standard, and in toxicological studies introduces uncertainty that is more likely to overestimate than to underestimate risk
Spatial distribution	Historical soil results and neighboring soil gas results indicate localized area and small mass, so screening risk likely overestimates actual risk

** After resampling, only one location had calculated risk exceeding 10^{-6} (2×10^{-5} for residential scenario), primarily due to the pesticide chlordane*

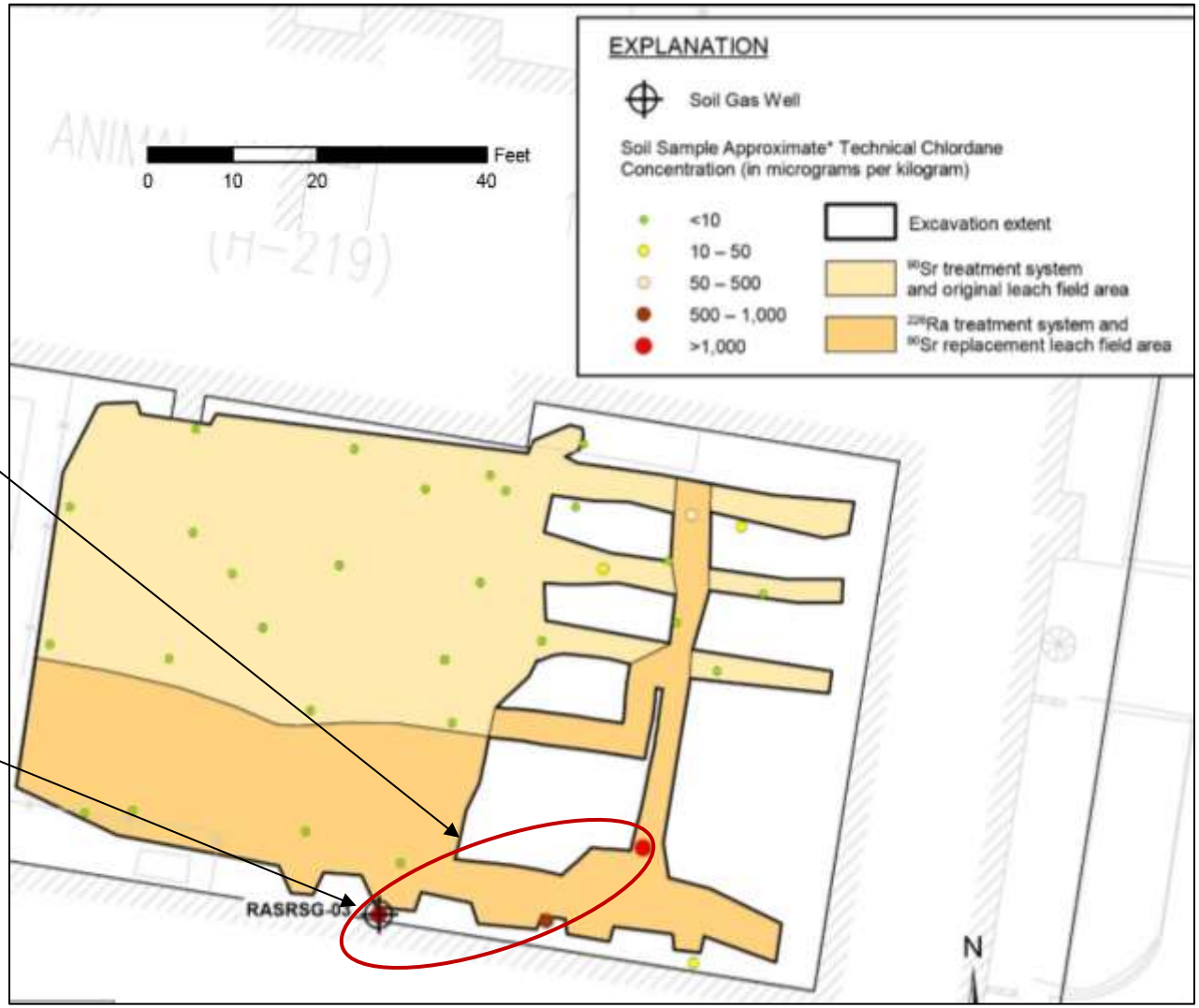
Use of VOC Attenuation Factor for LVVFCs



Spatial Distribution

Localized area with higher chlordane in excavation confirmation samples

Soil gas sample ~2 feet from highest soil concentration



Outcome of LEHR VI Evaluation

- The VI evaluation was successfully completed in 10 months
- Streamlined approach included:
  - Implementing a semi-quantitative passive soil gas survey for VOCs
  - Identifying and working with laboratories to develop sampling/analysis methods capable of achieving detection limits at or below the conservative risk standards
  - Communicating the technical rationale for a streamlined approach and using modified analytical methods to the regulatory agencies
  - Using multiple lines of evidence to demonstrate acceptable VI risk
- Report concluding no unacceptable VI risk was approved by EPA and California EPA in June 2018
- A five-year review addendum with new protectiveness statement was submitted to the regulatory agencies in July and approval is expected by September

The remedy at the DOE areas of LEHR is protective of human health and the environment.