Concepts for VI Source Containment or Interception

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U.S. EPA "State of VI Science" Workshop

Reliable Ongoing Human Exposure Protection to Vapor Intrusion Using Cleanup as the Simplest Approach

Disclaimer: The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of U.S. EPA.

40th Annual Conference on Soil, Water, Energy, and Air, A Hybrid Conference, October 22nd, 2024

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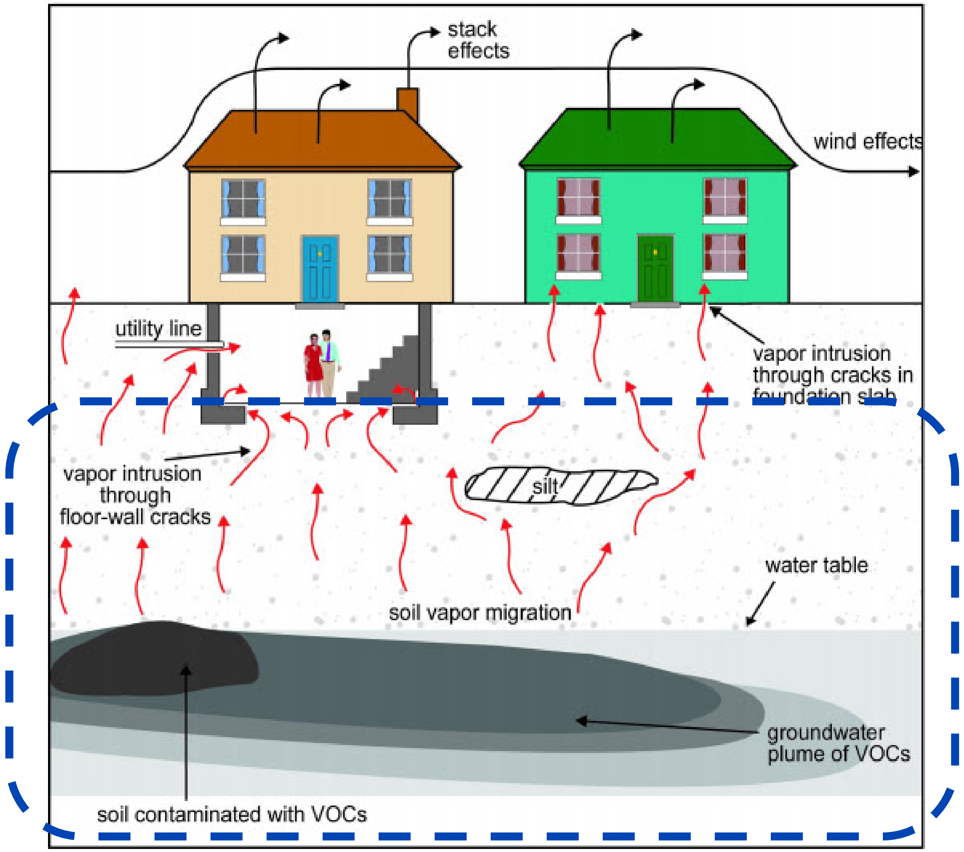
Outline

- Conceptual site model for control of soil vapors
- Sources & pathways in the natural environment
- Two case studies
- Concepts for soil vapor control & verification
- Recap



References: USEPA 2012, USEPA 2015

Focus of this presentation

February 2012 EPA 530-R-10-003

Conceptual Model Scenarios for the Vapor Intrusion Pathway

Conceptual Site Model for Soil Vapor Control

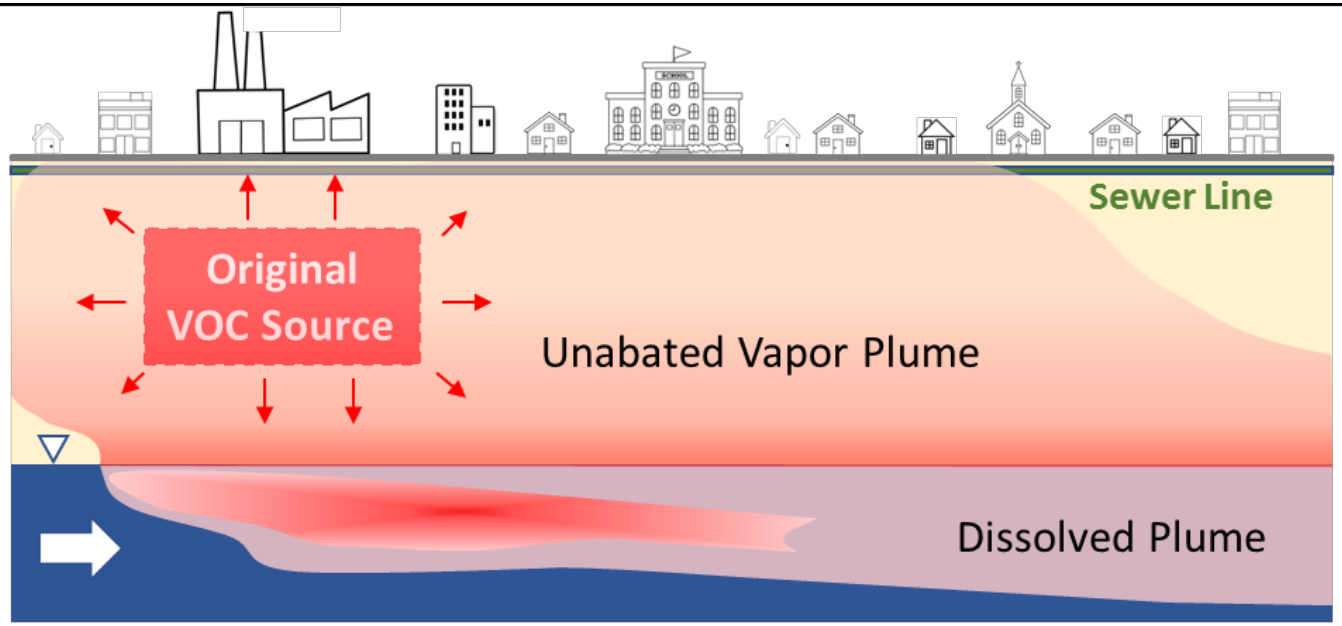
- Sources
  - Contaminants sequestered in built environment
  - **Underlying GW contamination**
  - **"Local" sources in the vadose zone**
- Pathways
  - Built environment (eg, sewer pipes, cracks)
  - **Migration through the natural environment**

Understanding vapor migration in the vadose zone allows control of soil vapors

Sources and Pathways in Natural Environment

- Local Vadose Zone
  - Primarily lateral migration
- Groundwater Plumes
  - Primarily upward vertical migration
  - Co-mingles with the vapor plume

The "source" of contaminated vapors evolves over time with remedial actions



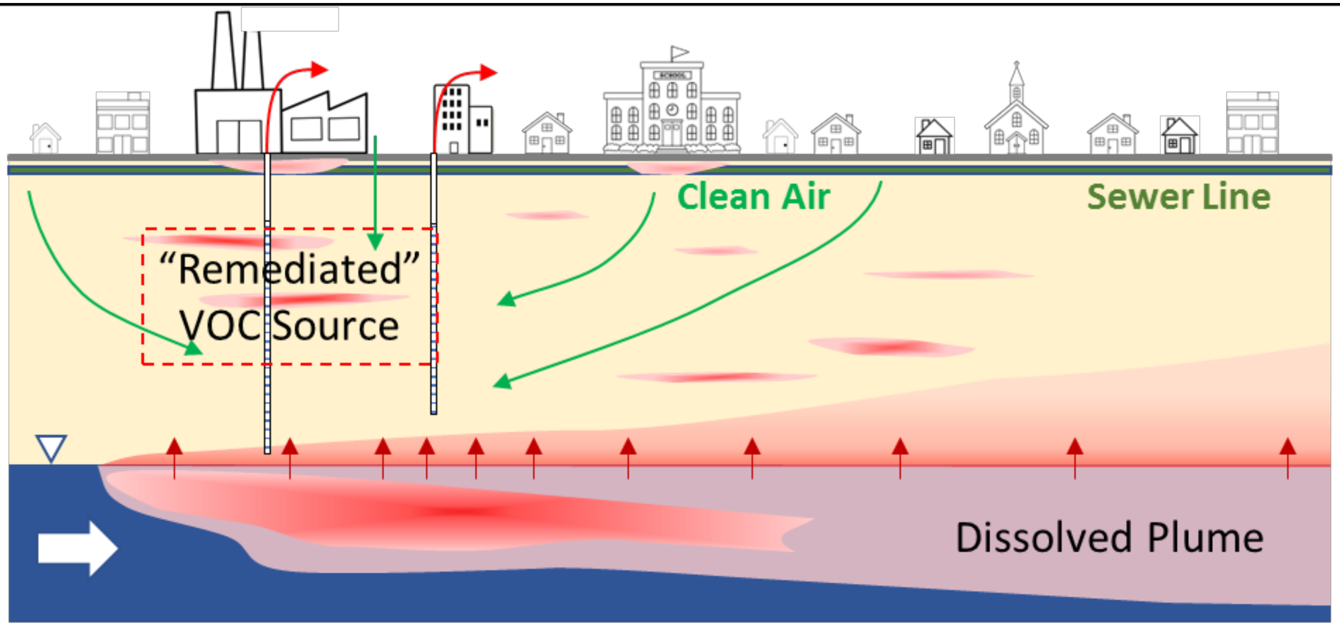
"Original Source" – released contaminant mass produces a persistent vapor plume

Contaminated groundwater migrates further and further downgradient

Sources and Pathways in Natural Environment

- Local Vadose Zone
  - Initial cleanup is “complete” but mass remains
- Groundwater Plume
  - Primarily upward vertical migration
  - Vapor plume is fed by volatilization from groundwater

Original source of contaminated vapors is largely reduced but residuals remain scattered over a large volume



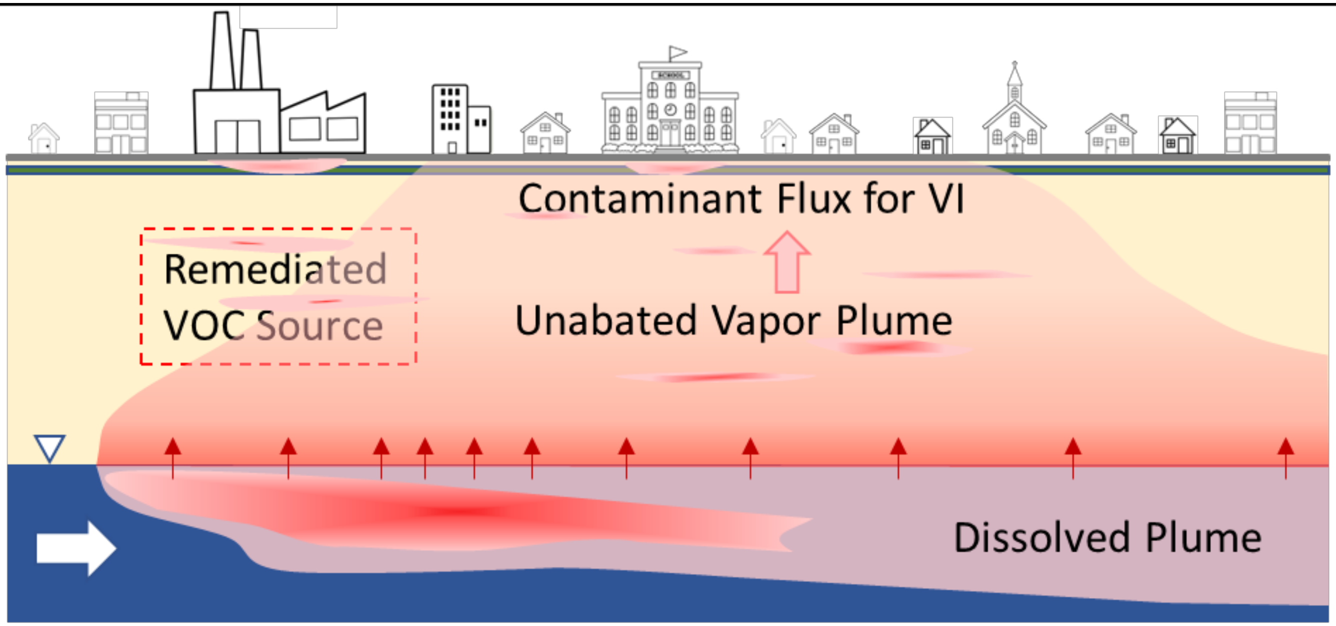
“Original Source” is gone! At least mostly, residuals remain. “Low levels” of VOC are in the soil gas

Contaminated groundwater now produces VOC vapors; it’s a **SOURCE**

Sources and Pathways in Natural Environment

- Local Vadose Zone
  - Residual mass remains at levels resulting in significant rebound
- Groundwater Plumes
  - Primarily upward vertical vapor migration
  - Vapor plume is fed by volatilization from groundwater

During remedial decisions on groundwater cleanup, vapor concentrations rebound



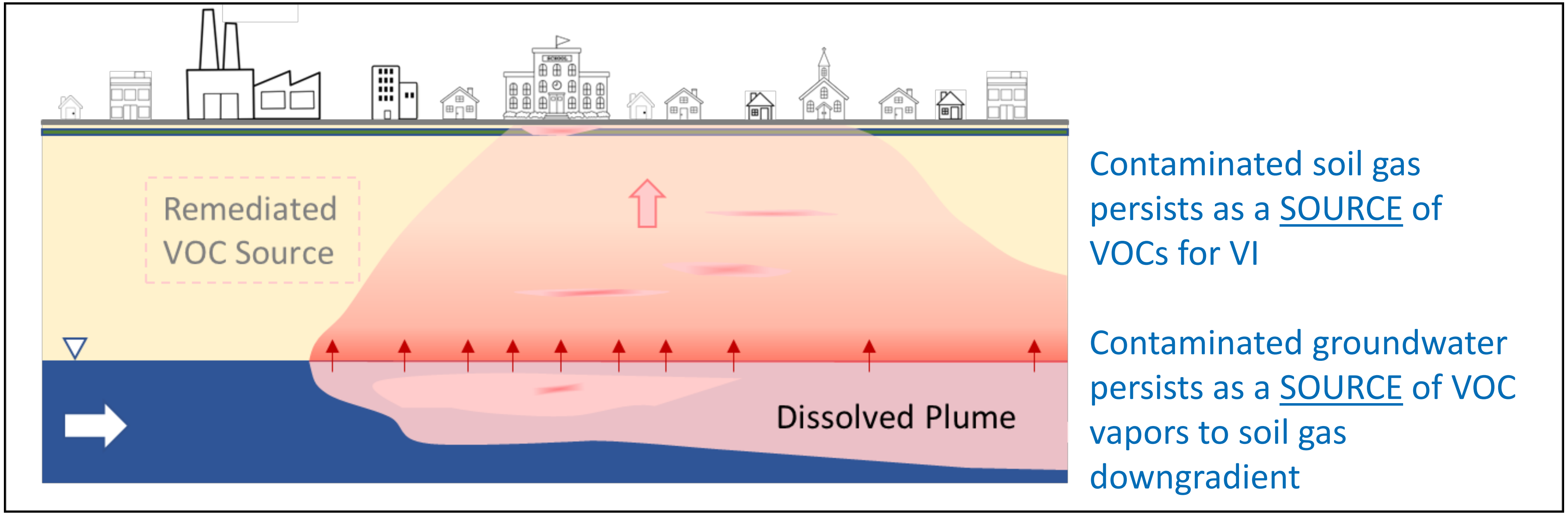
Contaminated soil gas is a source of VOCs for VI

Contaminated groundwater is a source of VOC for soil vapors

Sources and Pathways in Natural Environment

- Evolving Residual Sources
  - Appear after concentration gradient reversal
  - Natural environment (fine-grained sediments, perched water)
  - Built environment (concrete)

Responsible party is “done”, MNA will take care of the residuals. Or will it?



Case Study in Southern California

- Dense urban setting with mixed commercial /manufacturing/ homes
- Site was a metal plating shop using solvents (PCE)
- Prior SVE (1990's) and excavation remedies; VI indicated nearby

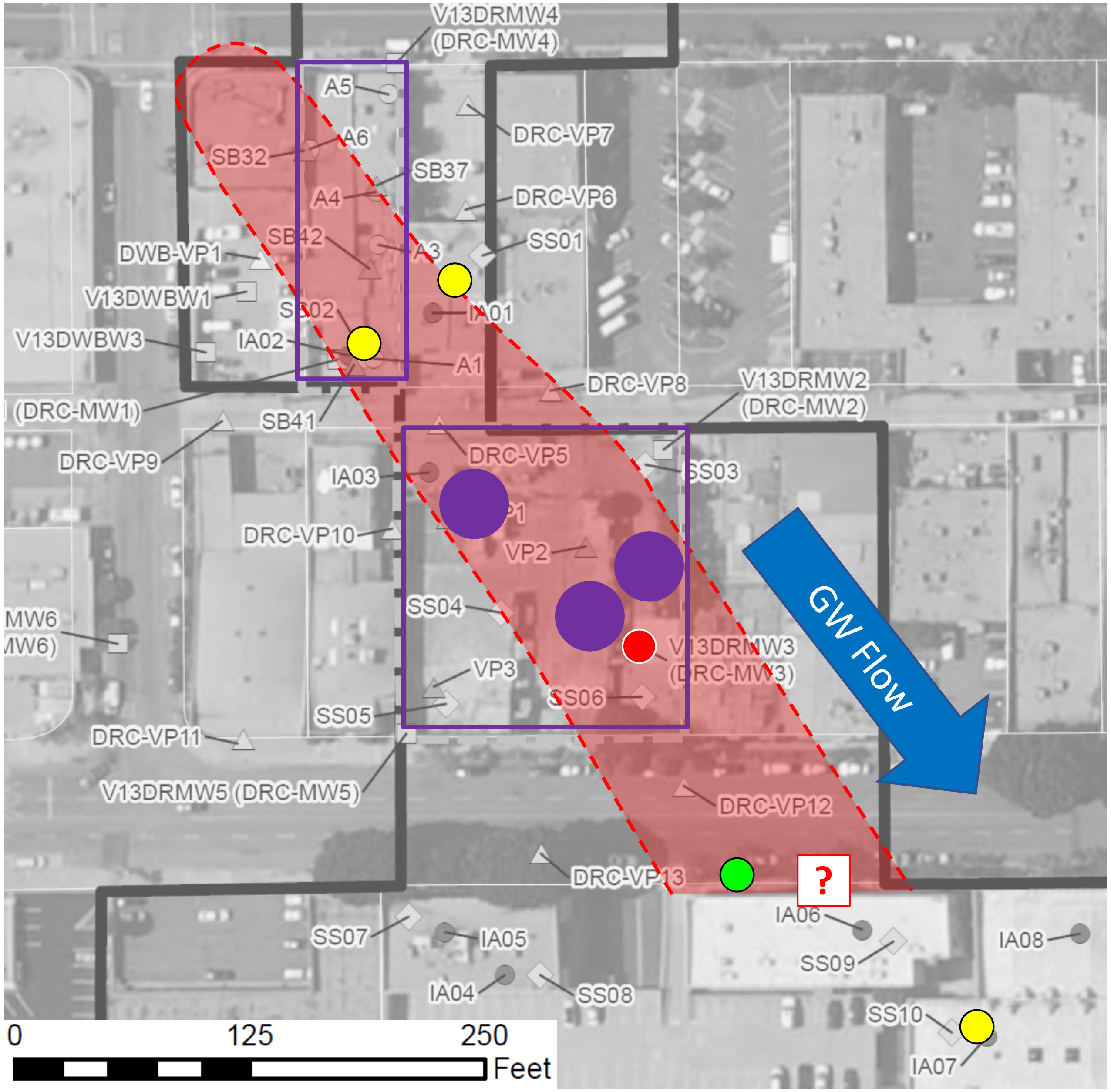
Suspected Surface Release Points

Suspected Groundwater Source Mass (Plume)

SS/IA Sampling

SVE Well

Subsurface Points



Case Study in Southern California

- Asphalt/Concrete Surface Cover
- 4 “model” soil layers
- Water table dropped from 45 to 65 ft bgs after release in ‘60’s – ‘80’s

Geology (pneumogeology?) governs VOC transport in the subsurface

Asphalt/Concrete Surface Cover

Depth	BSVE3	BSVE1	MW2	BSVE2	MW3	BSVE4	B26-1997	VP14
0.5	Concrete	Concrete	Asphalt	Concrete	Concrete		Concrete	Asphalt
1	SP	SP		SP			SP	SP
2	Asphalt/Bas	SP		SP			SP	SP
3	SP	SP		SP			SP	SP
4	SP	SP		SP			SP	SP
5	SM	SP		SP		SP	SP	[illegible]
6	SM	SP		SP		SP	SP	SP
7	SM	SP		SP		SP	SM	SP
8	SM	SP		SP-SM		SP	SM	SP
9	SP-SM	SM		SP-SM		SP	SM	SP
10	SP	SM		SP-SM		SP	SM	SP
11	SP	SM		SP		SP	SM	SP
12	SP	SM		SW		SP	SP	SP
13	SP	SM		[illegible]		SP	SP	SP
14	SP	SM		[illegible]		SM	SP	SP
15	SP	SM		[illegible]		SM	SP	[illegible]
16	SW	SP		SW		SM	SP	SP
17	SP	SP-SM		SW		SM	SP	SP
18	SP	SP		SP		SM	SP	SM
19	SM	SP		SP		SM	SP	SM
20	SP	SP		SP		SM	SP	SM
21	SP	SP		SP		SM	SP	SM
22	ML	SP		SP		SM	SM	SM
23	ML	SP		SP		SP	SM	SM
24	ML	SP		SP		SP	SM	SM
25	ML	SP		SP		SP	SM	SM
26	SP	SP		SP		SP	SM	SM
27	SP	SP		SP		SP	GP	SP
28	SP	SP		SP		SP	GP	SP
29	SP	SP		SP		SP	GP	SP
30	SP	SP		SP		SP	GP	SP
31	SP	SP		SP		SP	GP	SP
32	SP	ML		[illegible]		SP	GP	SP
33	SP	SP		[illegible]		SP	GP	SP
34	SP	SP		[illegible]		SP	GP	SP
35	SP	SP		[illegible]		SP	GP	[illegible]
36	SP	SP		SP		SP	GP	SP
37	SP	SP		SP		SP	SP	SP
38	SP	SP		SP		SP	SP	SP
39	SP	SP		SP		SP	SP	SP
40	SP	SP	GP	SP	GP	SP	SP	SP
41	SP	SP	GP	SP	GP	SP	SP	SP
42	SP	SP	GP	SP	GP	SP	SP	SP
43	SP	SP	SP	SP	SP	SP	SP	SP
44	SP	SP	SP	SP	SP	SP	SP	SP
45	SP	SP-SM	SP	SP	SP	SP	SP	SP
46	SP	SP-SM	SP	SP	SP	SP	SP	SP
47	SP	SM	SP	SP-SM	SP	SP	SP	SP
48	SP	SM	SP	SM	SP	SP	SP	SP
49	SP	SM	SP	SP	SP	SM	SP	SM
50	SP	SM	SP	SP-SM	SP	SM	SP	SM
51	SP	SP	SP	SP-SM	SP	SM		SM
52	SP	SP	SM	SP-SM	SM	SM		SM
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55	SP	SP	ML	[illegible]	[illegible]	SM		SP
56	SP	SM	SP	[illegible]	[illegible]	SM		SP
57	SP	SM	SP	SP-SM	SP	SP		SP
58	SP	SP	SP	SM	SP	SP		SP
59	SP	SP	SP	SM	SP	SP		SP
60	SP	SP	SP	SM	SP	SP		SP
61	SP	SP	SP	SP	SP	SP		SP
62	SP	SP	SP	SP	SP	Bottom at 61.5		Bottom at 6
63	SP	SP	SP	[illegible]	[illegible]			
64	SP	SP	SP	[illegible]	[illegible]			
65	Bottom at 6	Bottom at 6	SP	[illegible]	[illegible]			
66			SP	[illegible]	SP			
67			SP		SP			
68			SP		SP			
69			SP		SP			
70			ML		ML			

Silty Sand

Sand

Silt

Sand

~ Sand 47 ft
Silt Interface

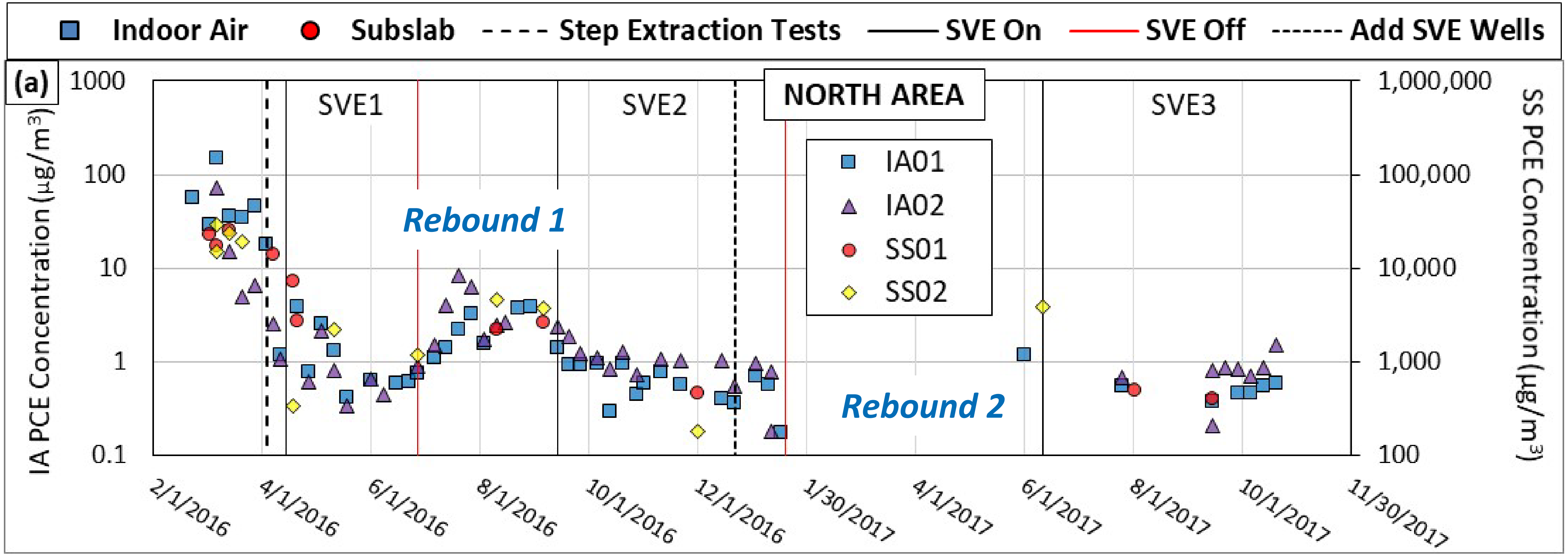
65 ft

Case Study in Southern California

<u>Results from monitoring wide-area effectiveness</u>

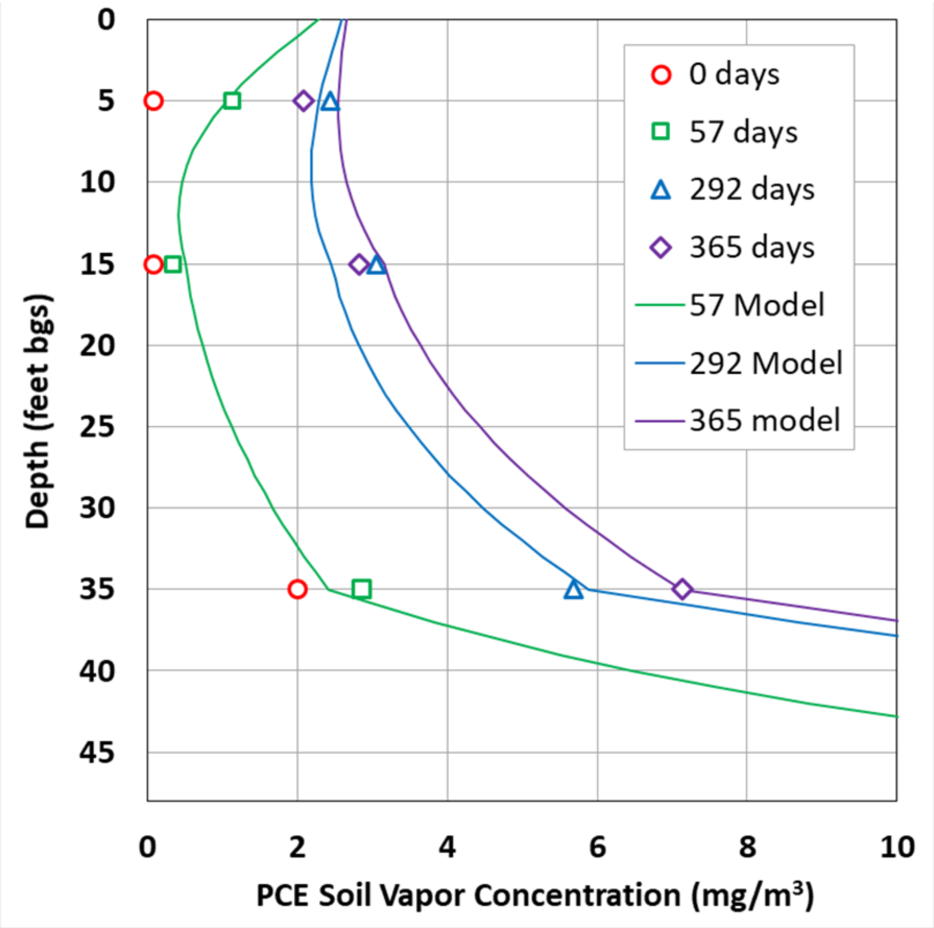
"***Field Study of Soil Vapor Extraction for Reducing Off-Site Vapor Intrusion***", Groundwater Monitoring & Remediation, Jan 2020, https://doi.org/10.1111/gwmr.12359

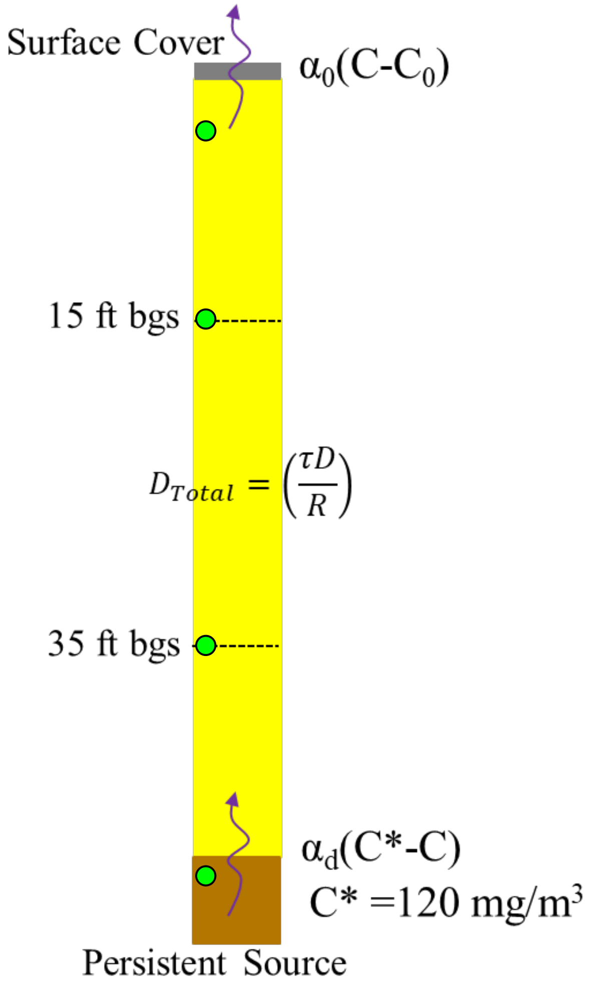
SVE reduces IA and SS concs at buildings 100-200 ft away

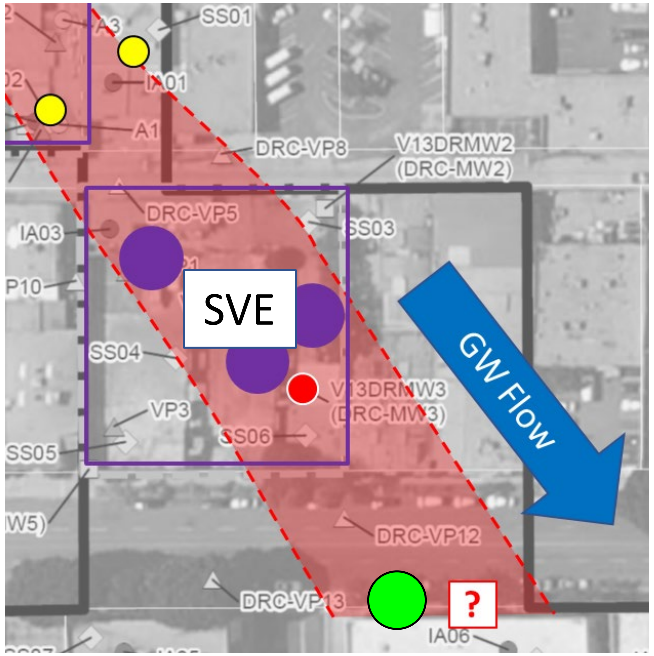


Case Study in Southern California

Evaluation of 1-year of Rebound



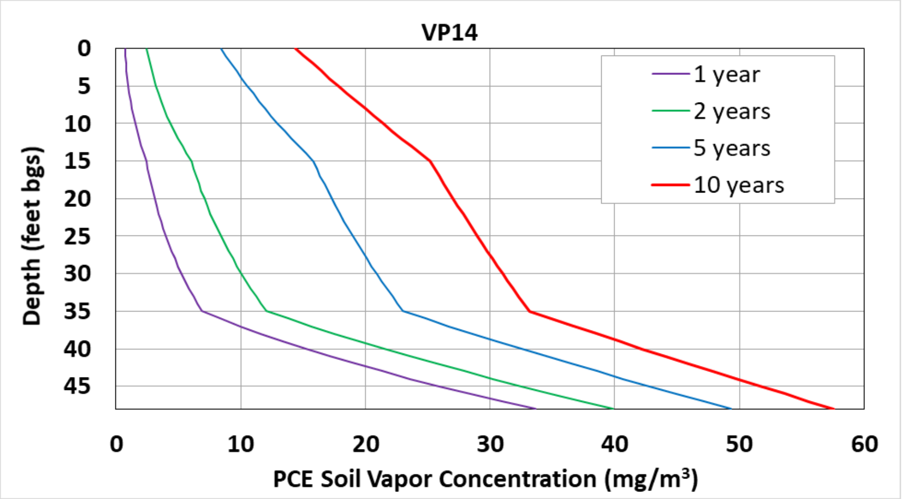


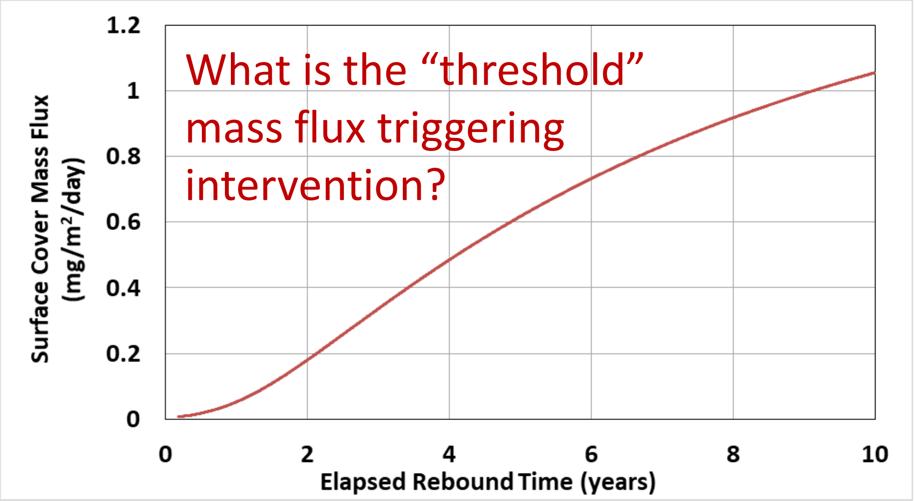


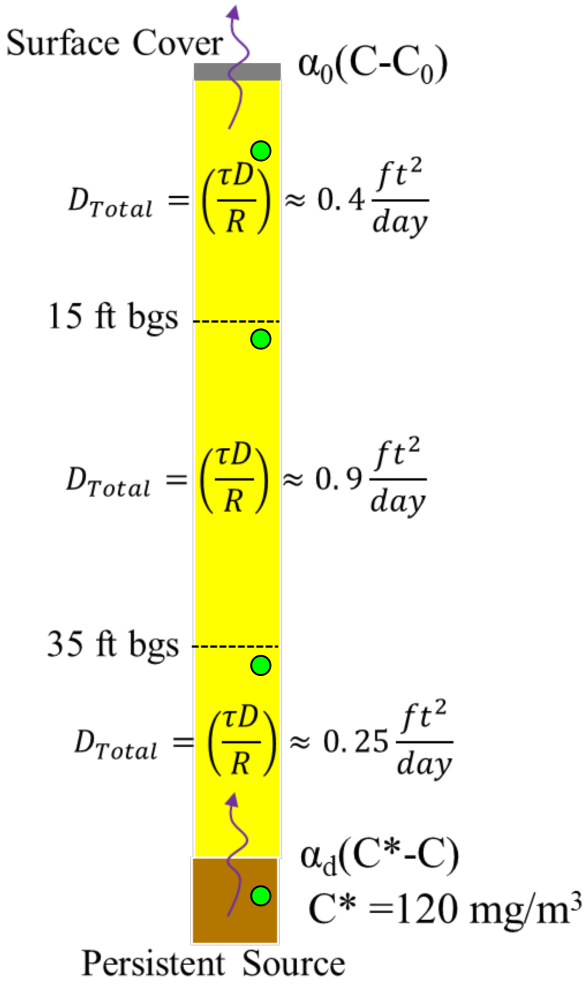
Rebound transients provide reliable data for assessing vapor diffusion coefficients

Case Study in Southern California

Evaluation of Continuous SVE vs Cycling



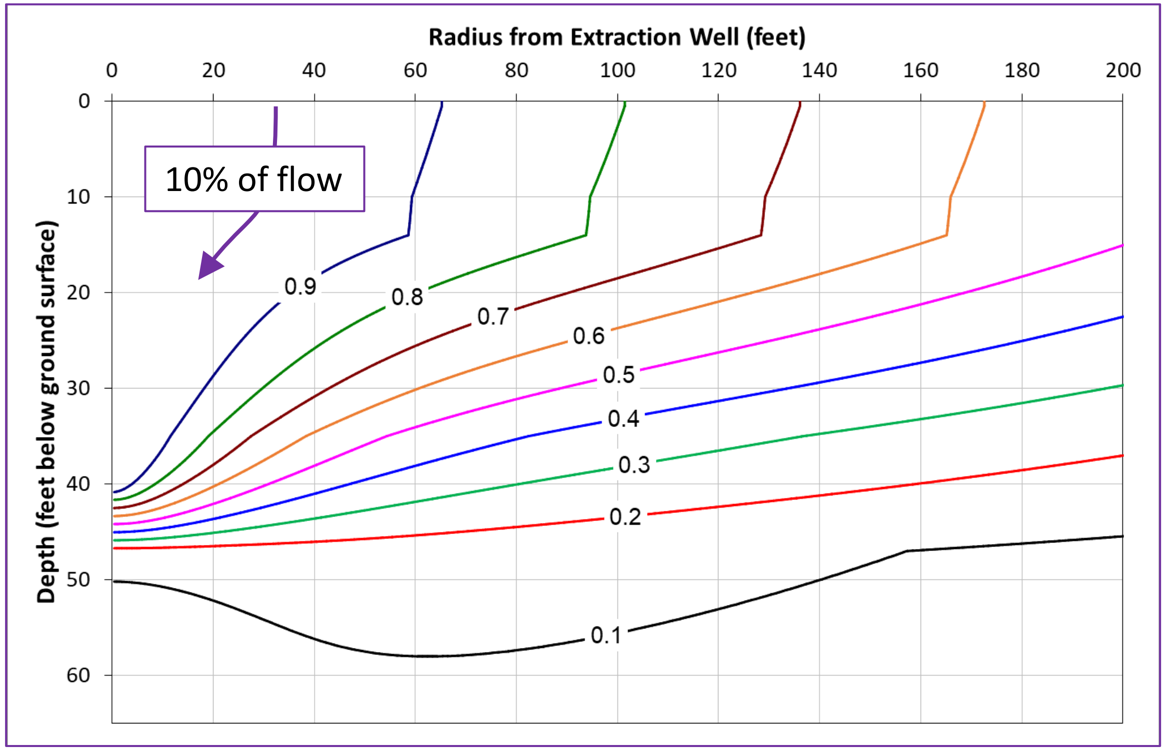




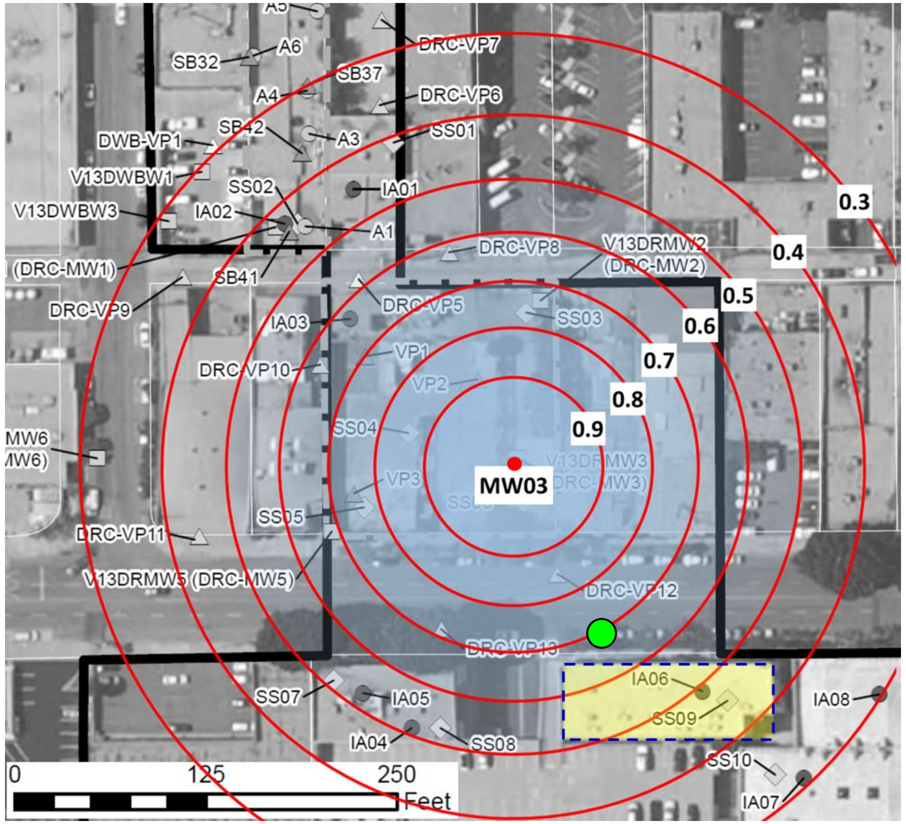
Calibrated transport parameters are reliable predictors; assumed parameters are not.

Case Study in Southern California

Evaluation of Full-Scale SVE vs Soil Gas Containment

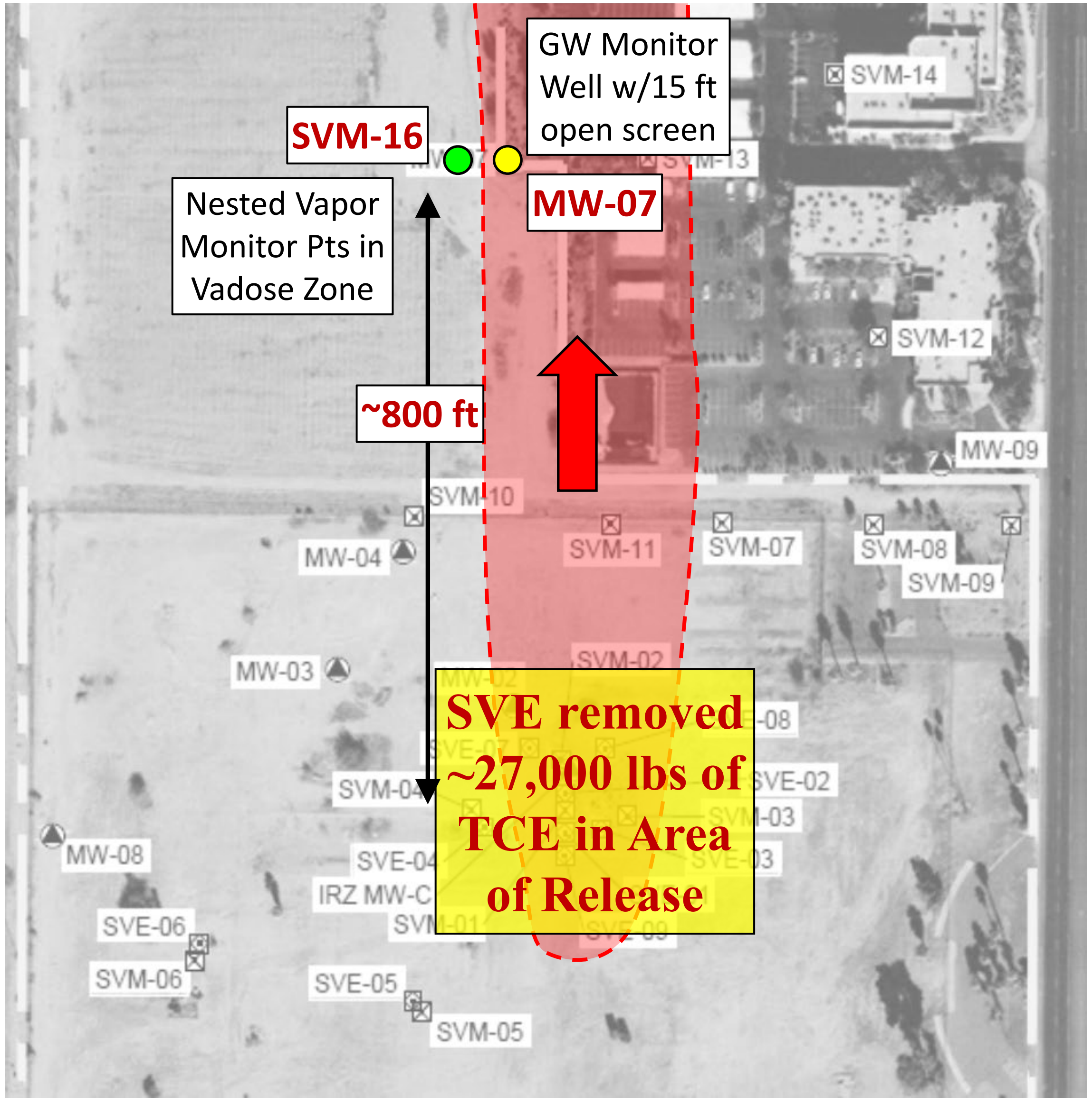


Groundwater monitoring well re-purposed for soil vapor control



“***Analytical Solutions for Steady-State Gas Flow in Layered Soils with Field Applications***”, Groundwater Monitoring & Remediation, January 2022, https://doi.org/10.1111/gwmr.12496

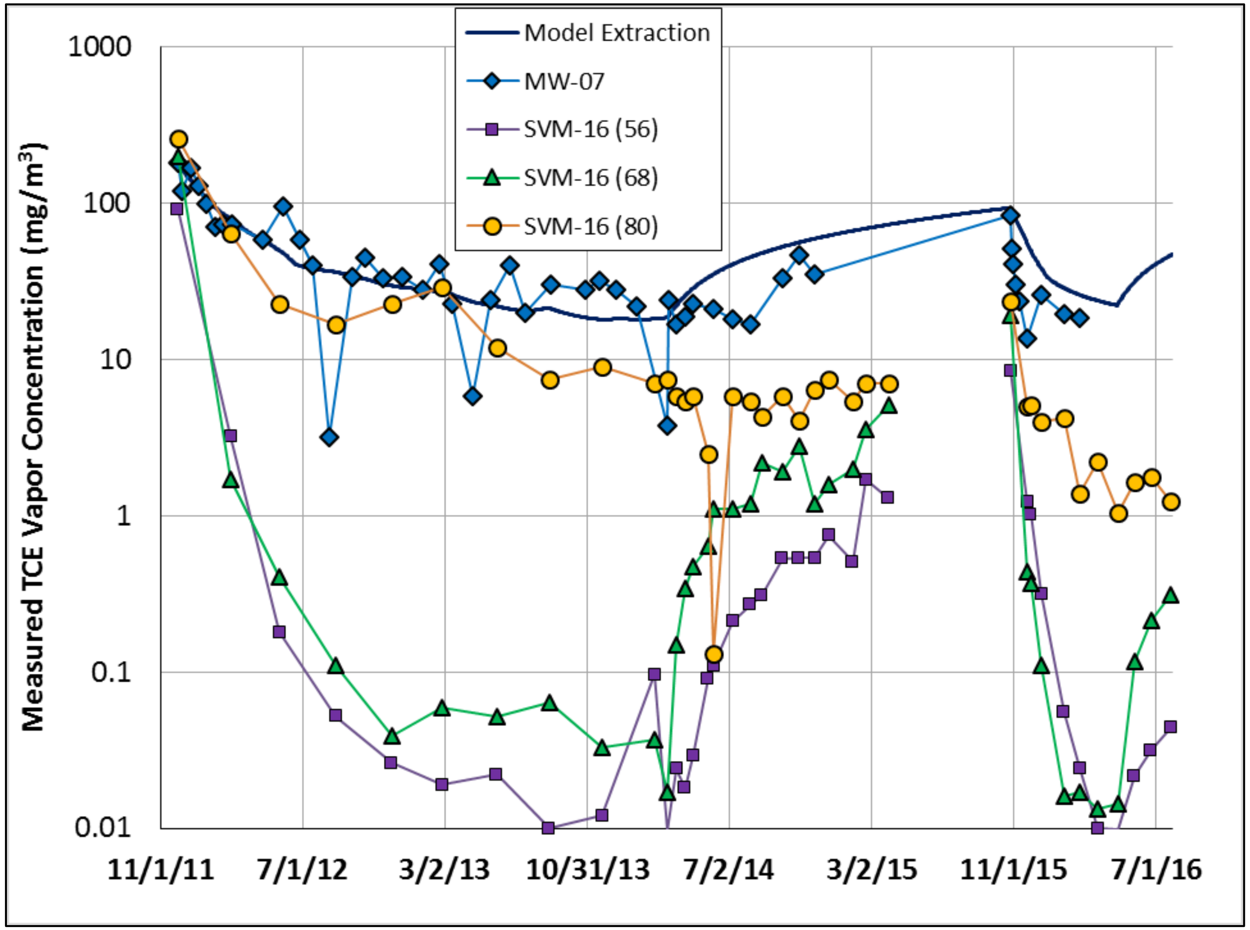
Case Study in Arizona



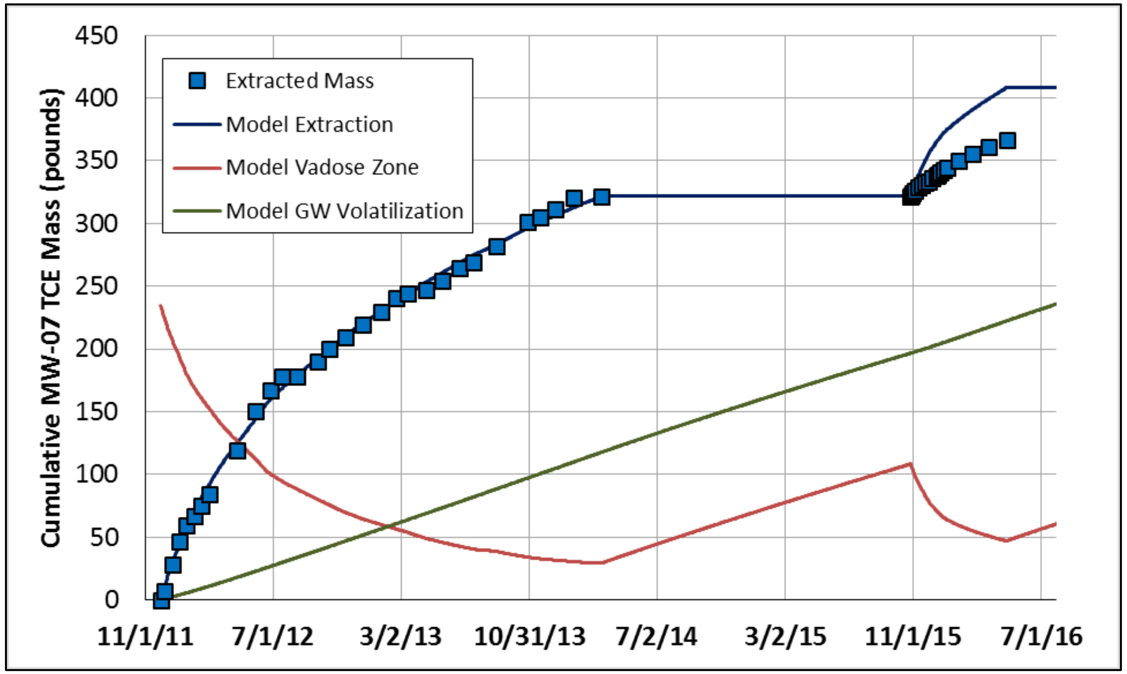
Site Conditions & Remedial History

- 2 decades of SVE removed ~27,000 lbs of TCE from Area of Release
- SVE added to MW-07 removed ~360 lbs
- MW-07 is ~800 feet downgradient
- Water table at ~97 ft bgs
- Clay unit from 45 to 50 ft bgs provides a partial vertical barrier
- Concerns for VI into overlying office buildings

Case Study in Arizona



- SVE can reach far laterally and vertically to reduce vadose zone vapor concs
- SVE contributes to GW cleanup



Design and Operational Concepts for Soil Vapor Control & Verification: SVE

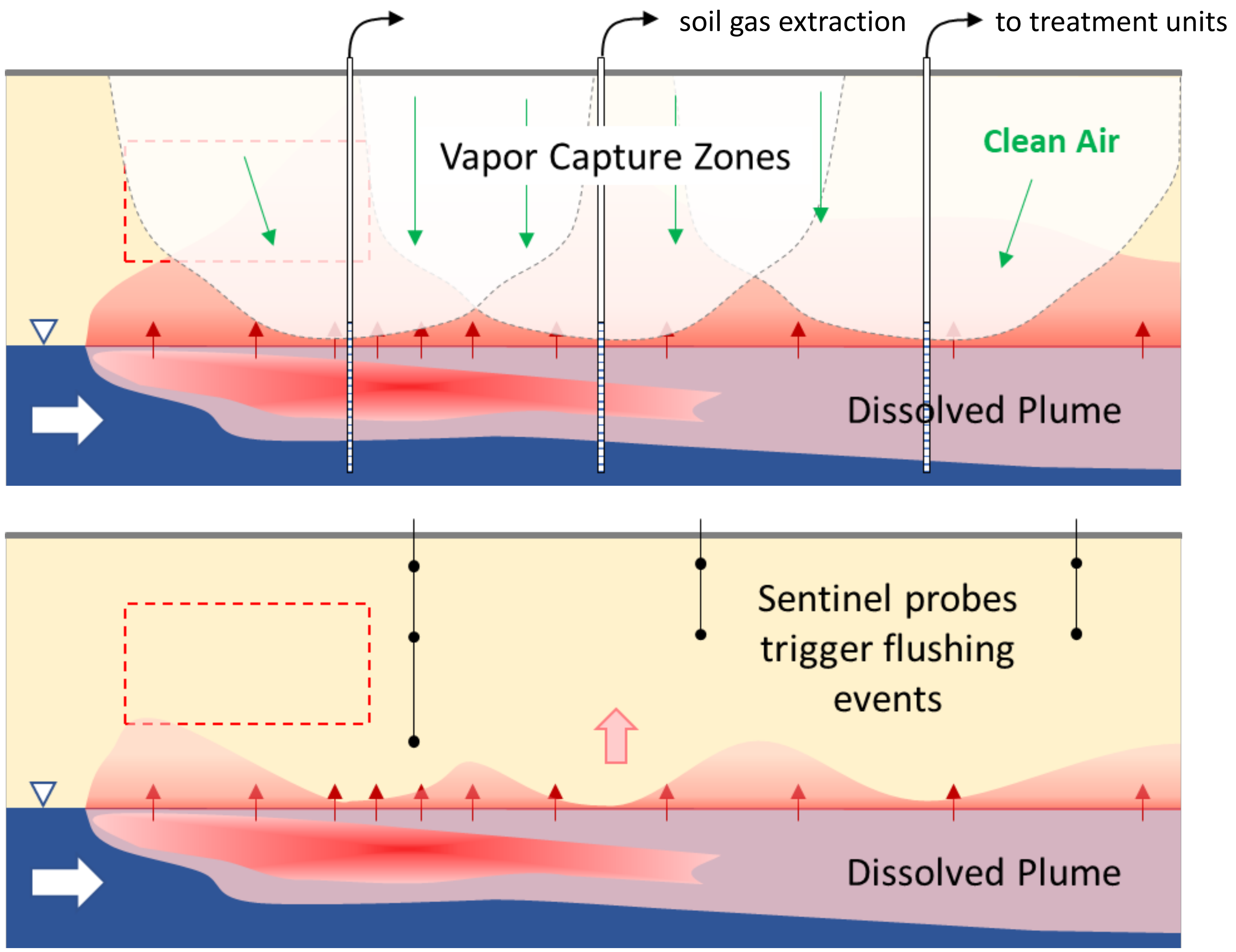
[Vapor Sweep Rate] > [Vertical Mass Transport Rate] = [No opportunity for VI]

Operation is analogous to exchange rates in buildings

Design Issues:

- How far does SVE reach laterally?
- What flow rate and duration provide adequate flush?
- How frequently does the zone require flushing?
- What are appropriate "sentinel" depths and concentrations?

Design and Operational Concepts for Soil Vapor Control & Verification: SVE



Flushing several soil gas pore volumes suppresses the vapor plume, TEMPORARILY

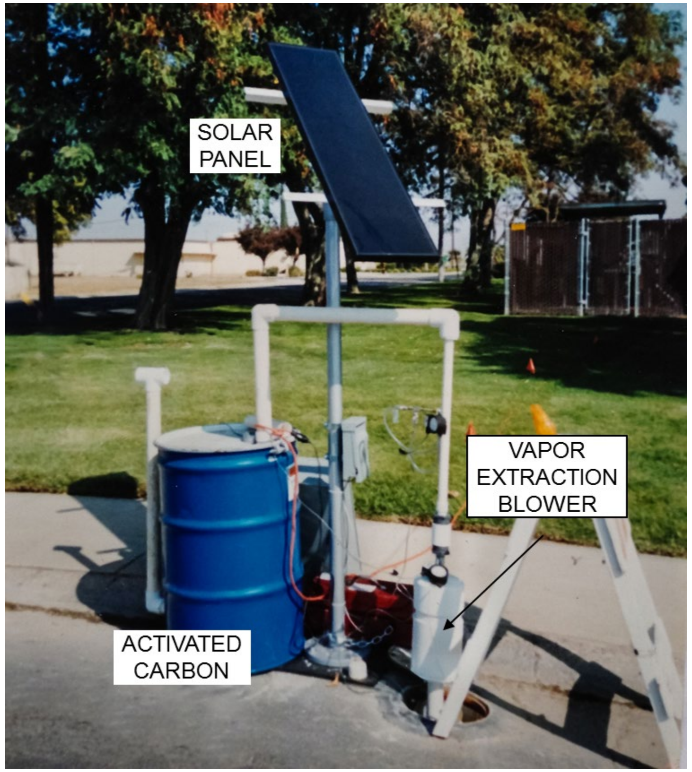
Periodic monitoring of sentinel probes until a threshold concentration is detected; triggers flushing event

Design and Operational Concepts for Soil Vapor Control & Verification: SVE

Site Characteristics for Assessing Applicability & Design

- Water table depth (if shallow, SSD is SVE!)
- Soil geology/stratigraphy
- Surface infrastructure / accessibility
- Groundwater/vapor concentrations

Re-purposing groundwater monitoring wells with exposed screen for vapor extraction is clearly my favorite approach

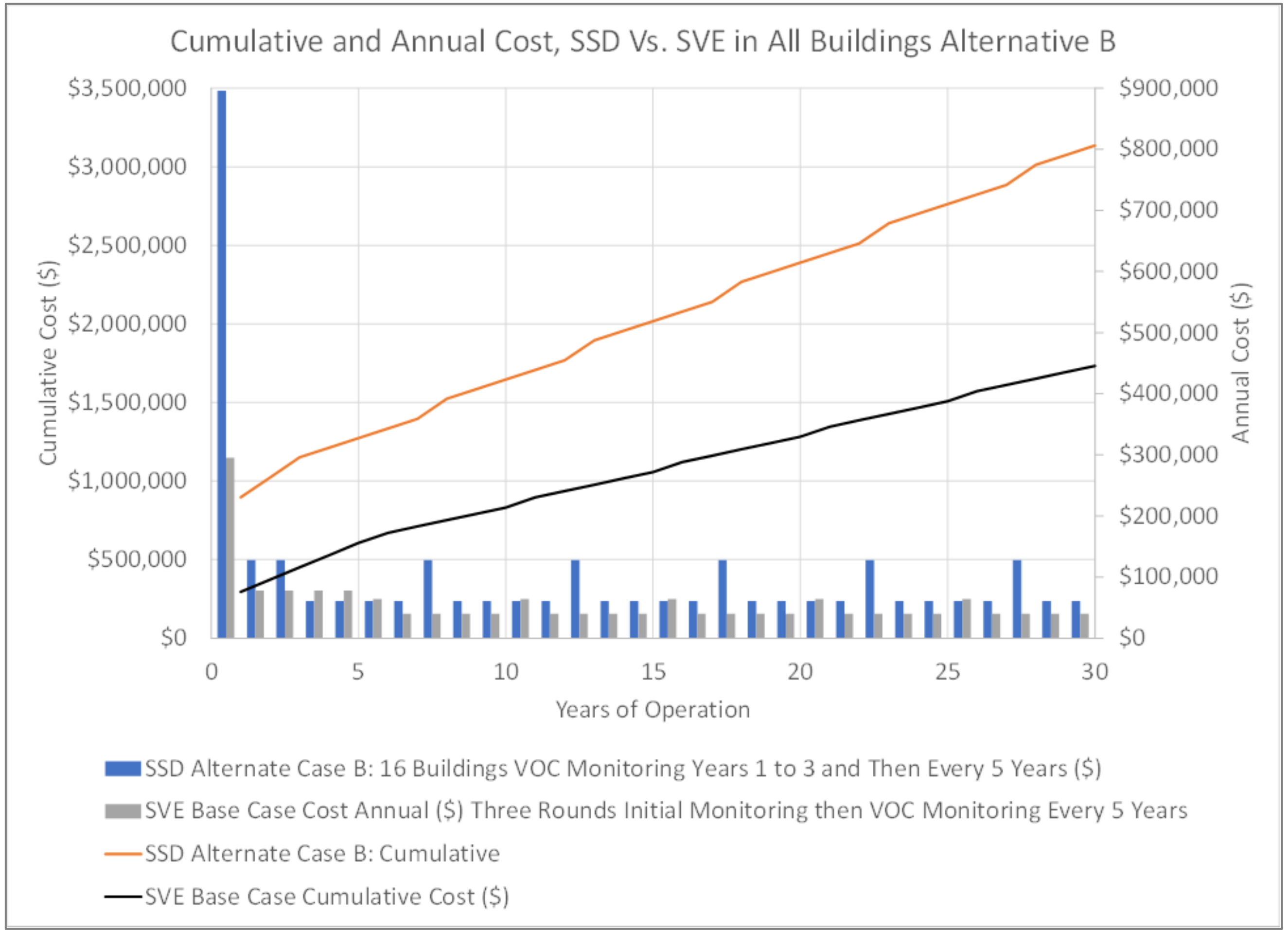


Economic Analysis for Soil Vapor Control

<u>Assess cost effectiveness</u>

"***Cost Comparison of Soil Vapor Extraction and Subslab Depressurization for Vapor Intrusion Mitigation***", GWM&R, Spring 2022 https://doi.org/10.1111/gwmr.12510

Cost comparison of individual 16 SSD systems vs cycling an SVE system (see Chris' bullets)



Design and Operational Concepts for Soil Vapor Control & Verification: Barriers

[(Barrier Attenuation)(Source Conc)] < [VISL] = [No opportunity for VI]*

Design Issues for barriers placed in the natural environment:

- How distant should the barrier be placed from pathways?
- Can the barrier's continuity be verified?
- What is the expected lifespan of the barrier?
- What are appropriate methods of verification?

EXAMPLES (Be Creative!)

- Deep Excavation with low-k fill
- Soil mixing with oxidant or GAC
- Edible oil layer
- ??? Be creative, site-specific

Recap

- Concentrations in the natural environment are demonstrably more consistent than the built environment
- Migration pathways in the natural environment are more easily controlled than pathways into buildings
- Soil vapor control & verification is best done distant from receptors (e.g., *community vs individual bldgs, reliable*)
- Subsurface samples can predict future; allow readily recognizable, verifiable, achievable goals
- Contaminated soil gas should be treated analogously to contaminated groundwater
- SVE, where applicable, is highly developed and well understood