U.S. EPA Vapor Intrusion Workshop

Vapor Intrusion Protection Cost-Effectiveness Simulation Tool (2.0)

Managing Vapor Intrusion Over Decades: Lessons from a Large Utah Site

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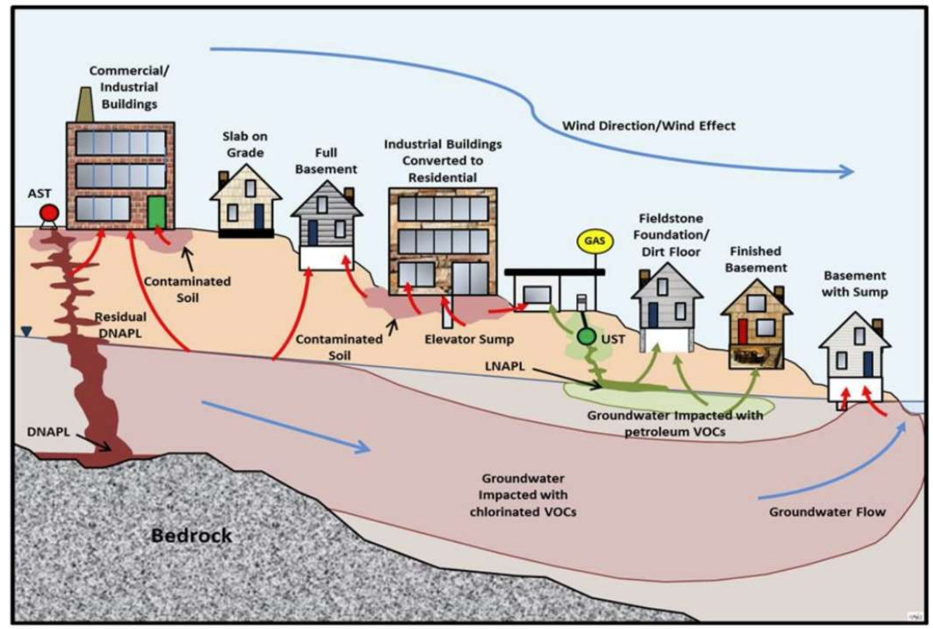
Agenda

- What makes long-term VI plume management so difficult?
- Hill AFB Basewide Indoor Air Program (OU15)
- Sun Devil Manor research (OU8, SERDP ER-1686)
- VI Diagnosis Toolkit (OU8, ESTCP ER-201501)
- Summary and Conclusions

What Makes Long-Term VI Plume Management so Difficult?

- Low and stable subsurface concentrations, yet high spatial variability
- Complex geology, topography, and/or infrastructure
- Evolution in vapor intrusion understanding (90's > 00's > 10's+) and ongoing assessment challenges
- Cost effective strategies and reaching closure

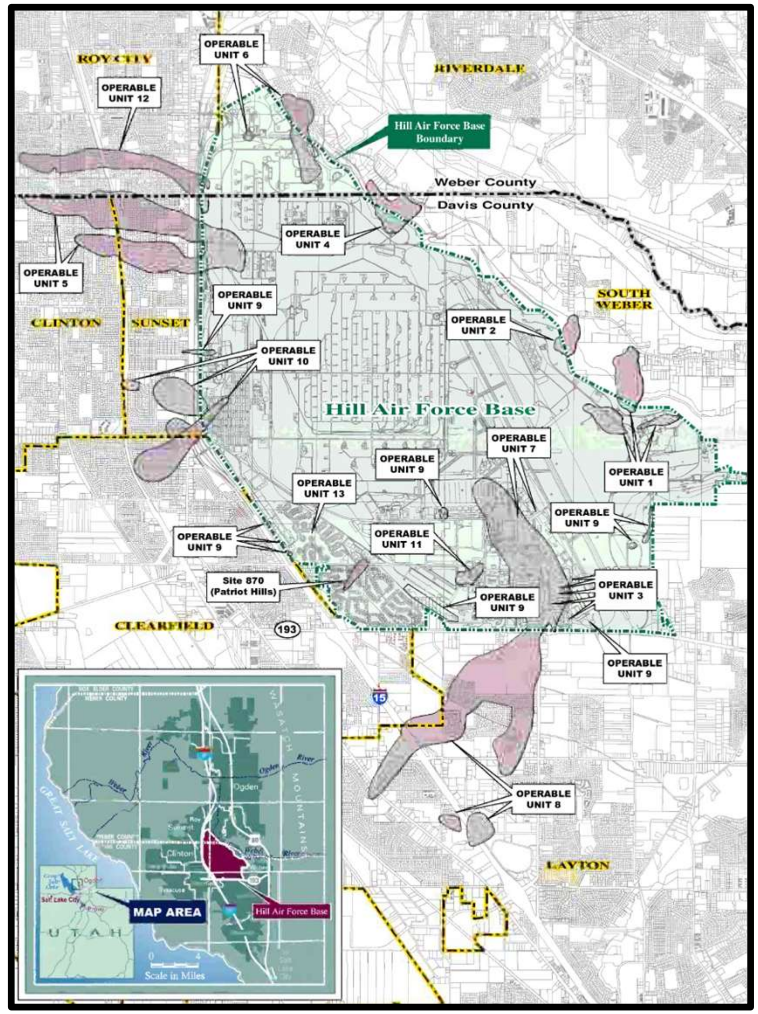


Adapted from Figure 2-1; Massachusetts Department of Environmental Protection (2016), Vapor Intrusion Guidance: Site Assessment, Mitigation and Closure

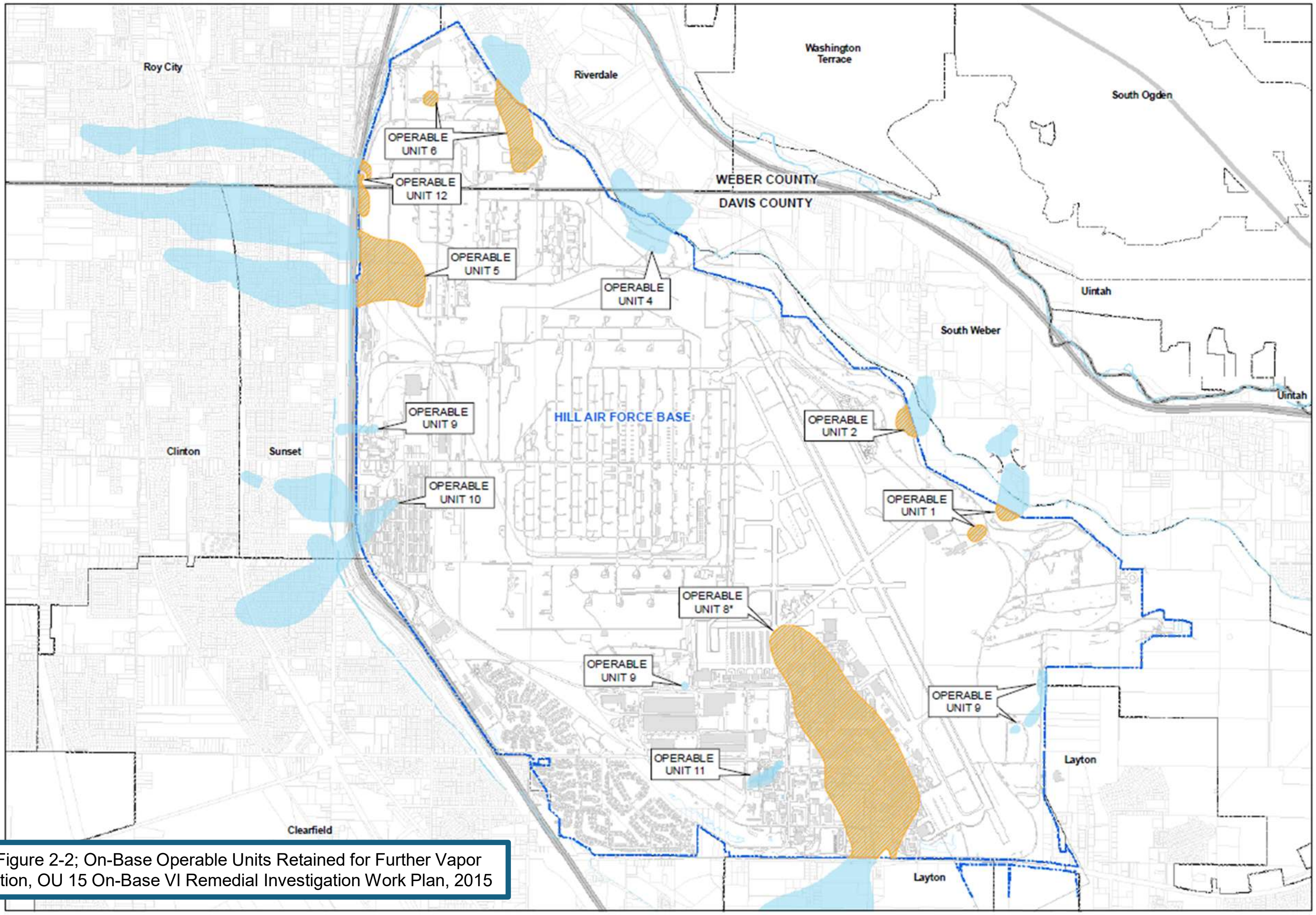
Hill Air Force Base
Northern Utah, OU15

Hill Air Force Base: OU15

- Northern Utah, air force base (AFB)
- Multiple chlorinated solvent-impacted groundwater plumes
- Basewide Residential Indoor Air Program began in 2003
  - Formalized operable unit (OU) 15
  - Standardized sampling approach (24-h)
  - Established Mitigation Action Levels (MALs) for PCE and TCE



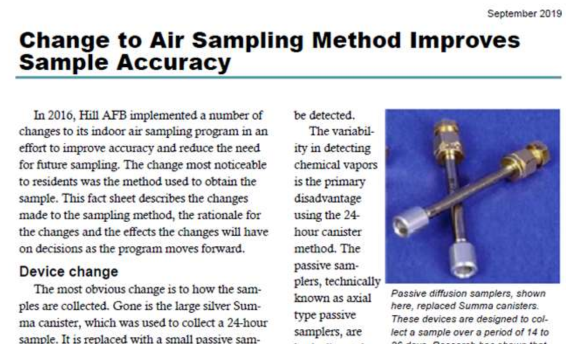
Adapted from Figure 1-1; MWH Americas, Inc., Indoor Air Program Technical Review Document (Nov. 2010), Hill Air Force Base, Utah.



Adapted from Figure 2-2; On-Base Operable Units Retained for Further Vapor Intrusion Evaluation, OU 15 On-Base VI Remedial Investigation Work Plan, 2015

Adaptive Management and Long-Term Stewardship

- >1,600 residences sampled; >5,000 indoor air samples collected (2010 – present);
- >120 buildings SSD systems installed
- Community engagement
- Developed/pioneered portable GC/MS assessment approach
- Adopted 14-to-26-day passive sampling approach (TO-17) in 2016



September 2019

Change to Air Sampling Method Improves Sample Accuracy

In 2016, Hill AFB implemented a number of changes to its indoor air sampling program in an effort to improve accuracy and reduce the need for future sampling. The change most noticeable to residents was the method used to obtain the sample. This fact sheet describes the changes made to the sampling method, the rationale for the changes and the effects the changes will have on decisions as the program moves forward.

Device change

The most obvious change is to how the samples are collected. Gone is the large silver Summa canister, which was used to collect a 24-hour sample. It is replaced with a small passive sam-

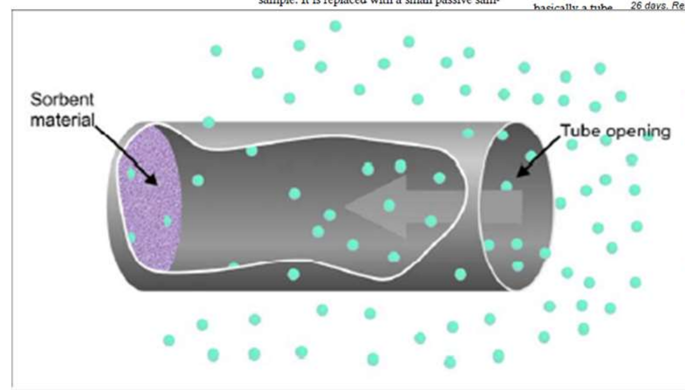
be detected.

The variability in detecting chemical vapors is the primary disadvantage using the 24-hour canister method. The passive samplers, technically known as axial type passive samplers, are

Passive diffusion samplers, shown here, replaced Summa canisters. These devices are designed to collect a sample over a period of 14 to 26 days. Research has shown that
n sample is more ef-
rmining if vapor intru-
ng in a home than a
le.

in the home, the
flow into them.
ng timeframe, the
boratory for anal-
an average con-
ir during the sam-

pproximate sam-
sampling up to
be able to deter-
sion is occurring
egree of certainty
same home multi-
l years.

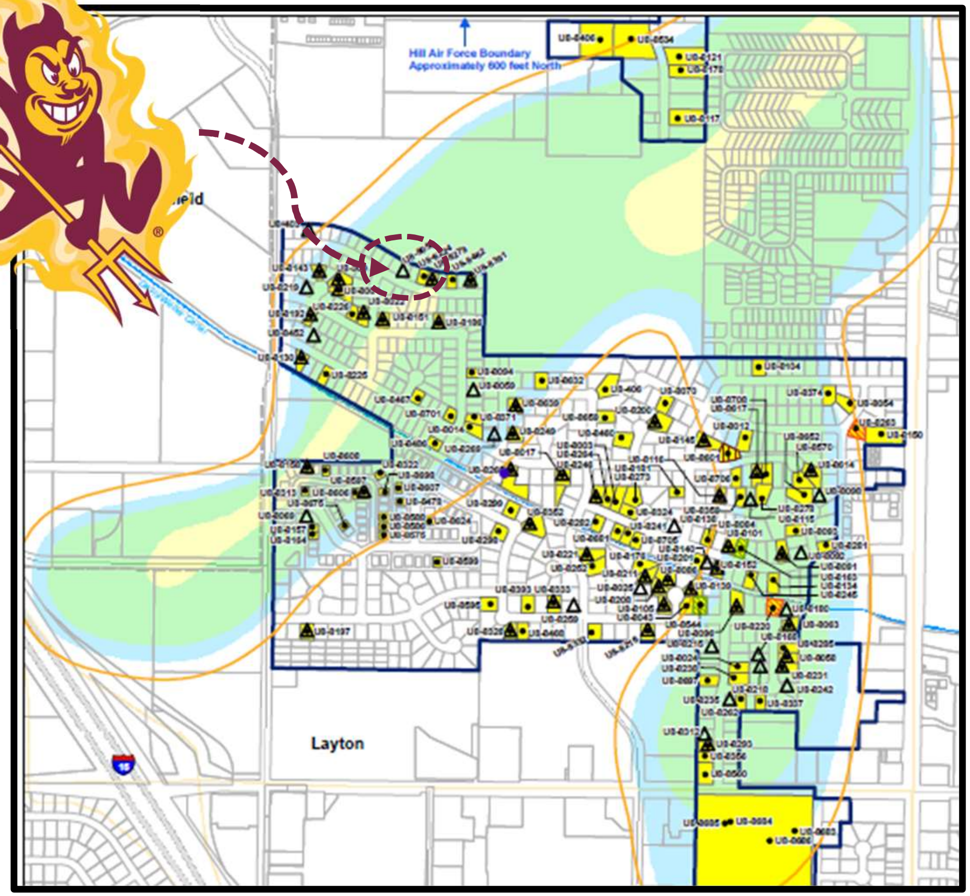


Adapted from Hill Air Force Base, *Change to Air Sampling Method Improves Sample Accuracy* (September 2019)

“Sun Devil Manor”
Layton, Utah; OU8
SERDP ER-1686 (2010 – 2015)

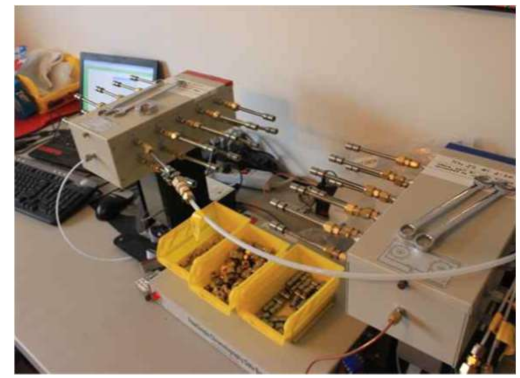
Sun Devil Manor

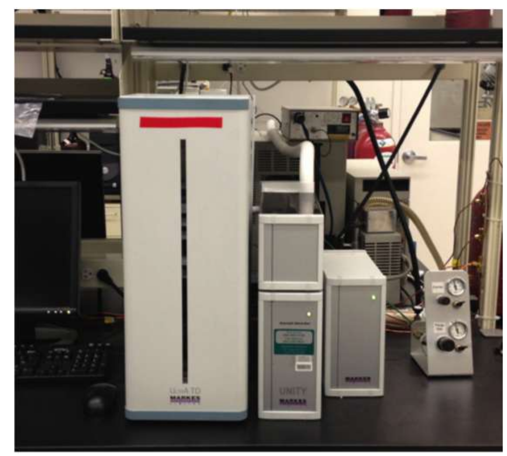
SERDP ER-1686



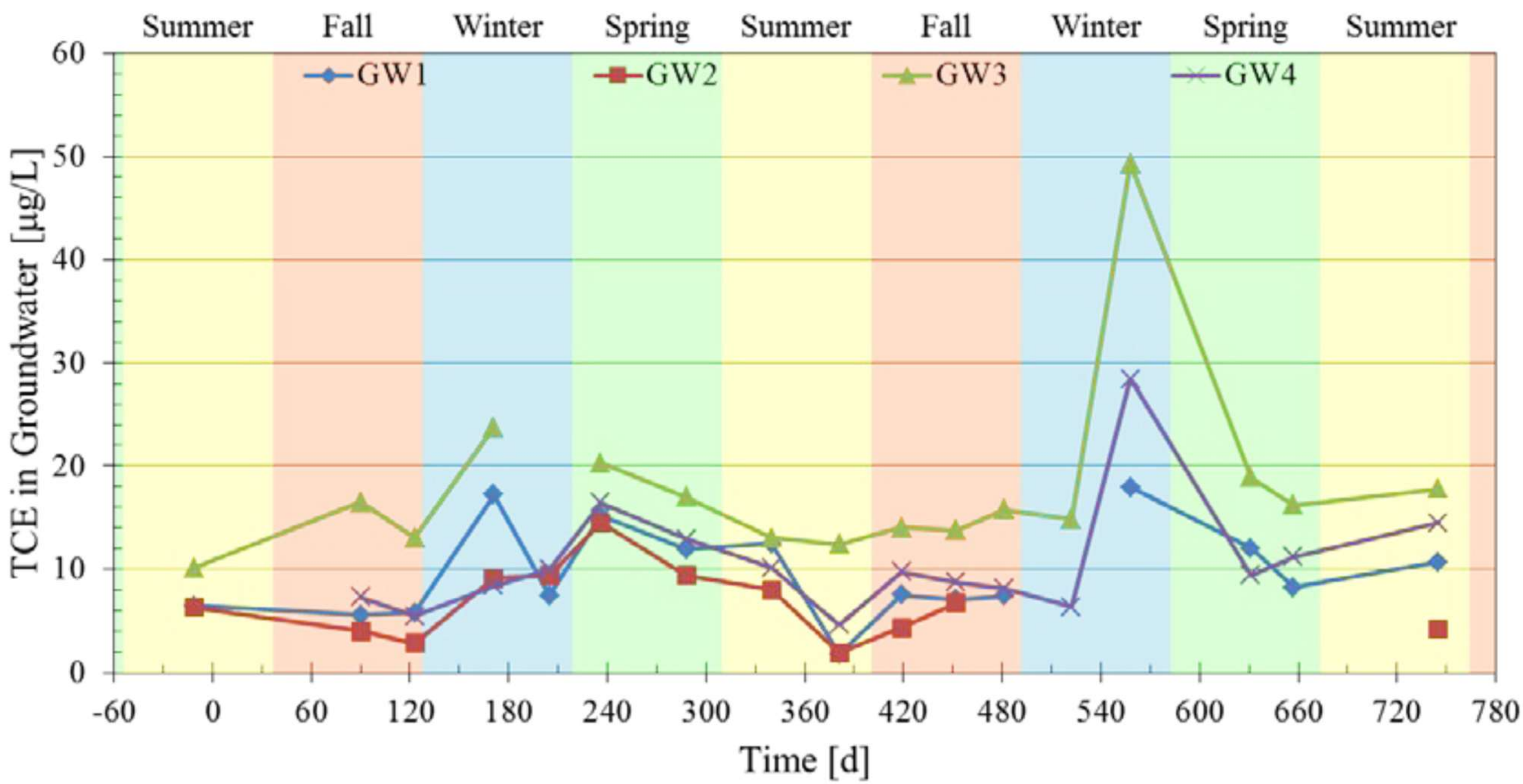
Adapted from Figure 4; EA Engineering, Science, and Technology, Inc.. Operable Unit 15 – Site ZZ113, Residential Indoor Air Program, Semi-Annual Air Program Report (Dec. 2015), Hill Air Force Base, Utah

SDM: Field Laboratory



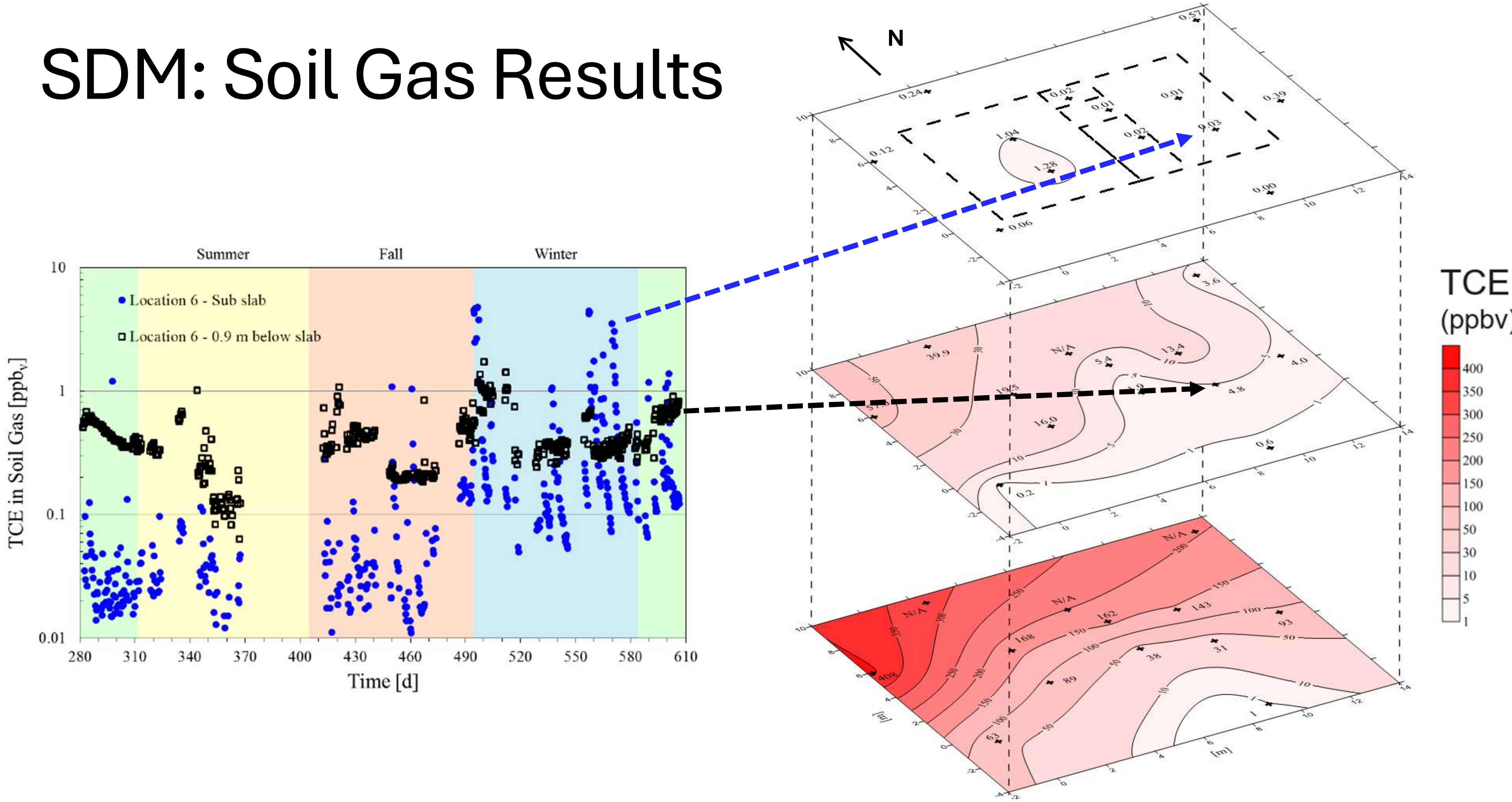


SDM: Shallow Groundwater



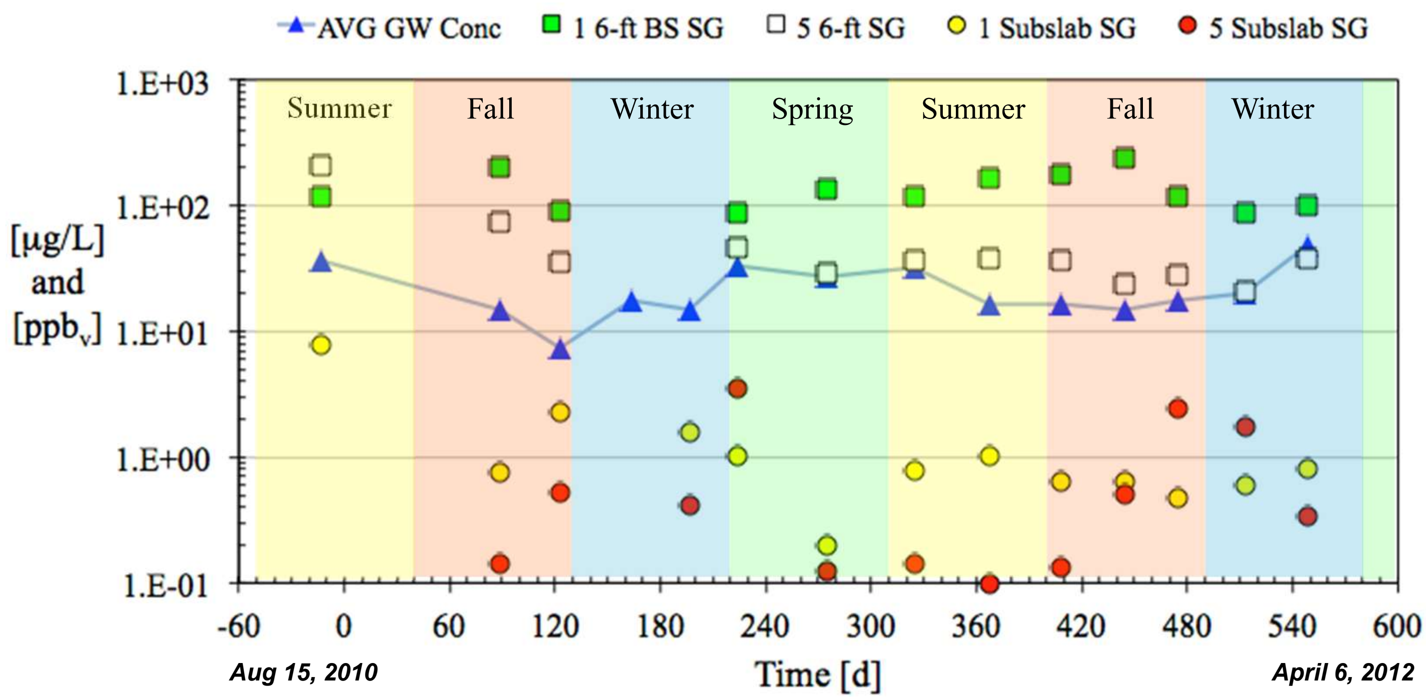
Adapted from Figure 4.10, SERDP ER-1686 Final Report, Johnson et al., 2016

SDM: Soil Gas Results



Adapted from SERDP ER-1686 Final Report, Johnson et al., 2016

SDM: VI Pathway Variability



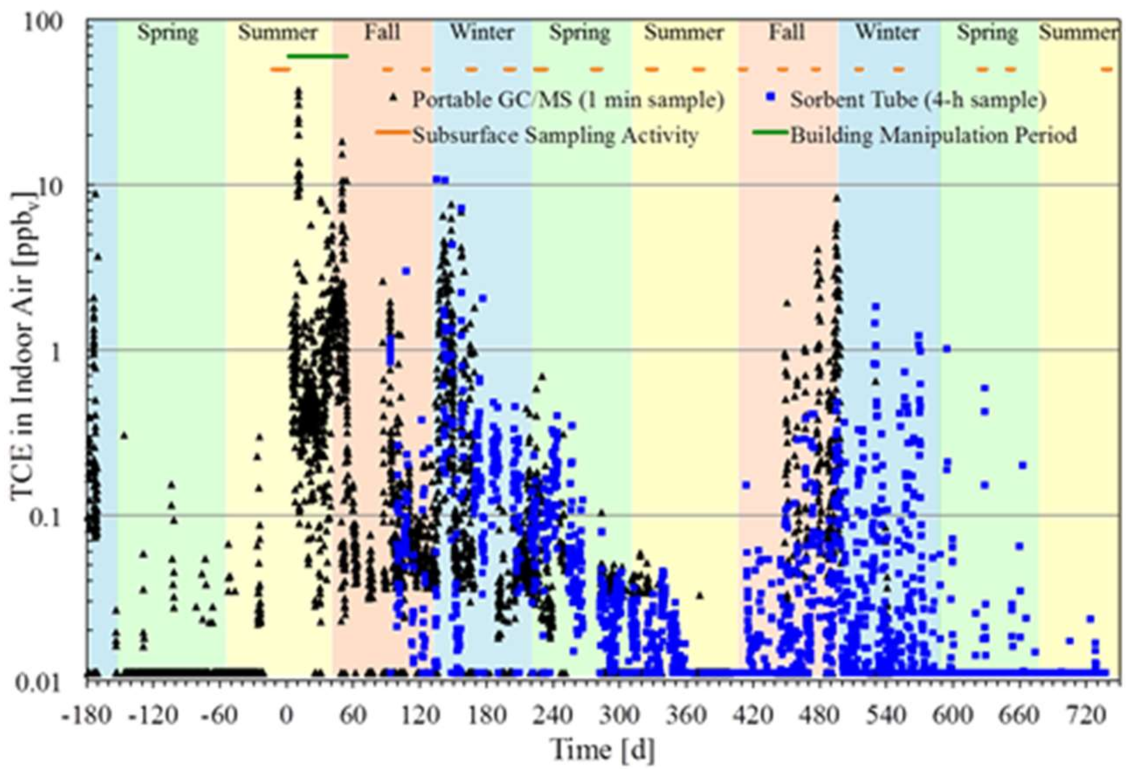
Media and Depth	Spatial Variations	Temporal Variations
Subslab Soil Gas	10X – 100X	10X
3-ft Below Slab Soil Gas	10X	2X
6-ft Below Slab Soil Gas	3X	50% (about mean)
Shallowest Groundwater	2X	50% (about mean)

Adapted from Holton et al., 2012, Differences in Temporal Signatures in Groundwater, Soil Gas, and Indoor Air Data and Implications for Pathway Assessment

SDM: Indoor Air Results

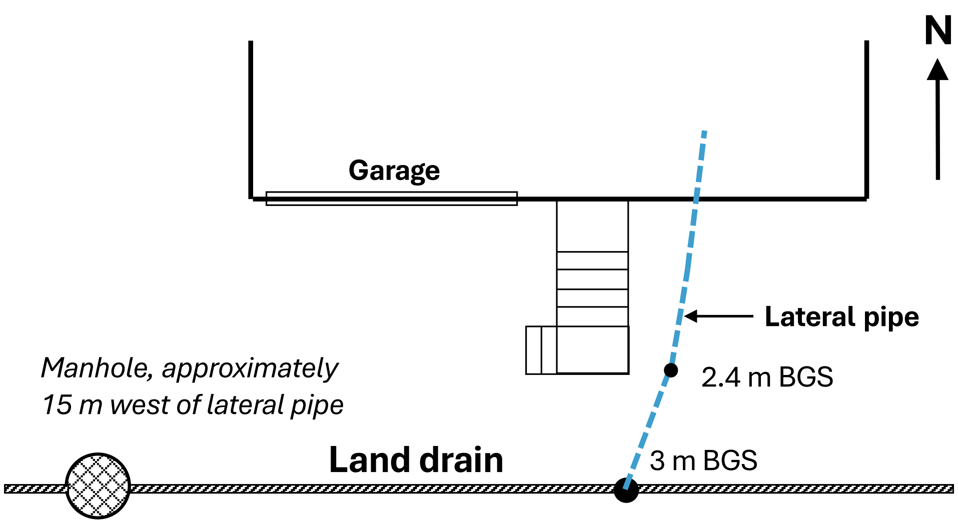
Natural Conditions (2010 – 2012)

- Temporal variability of 1-3 orders of magnitude
- Data used to demonstrate difficulty in characterize high temporal variability using conventional sampling approaches



Adapted from Figure 4, Holton et al., 2013, *Environmental Science & Technology*

Discovery of Land Drain Vapor Pathway



“VI Diagnosis Toolkit”

Layton, Utah; OU8

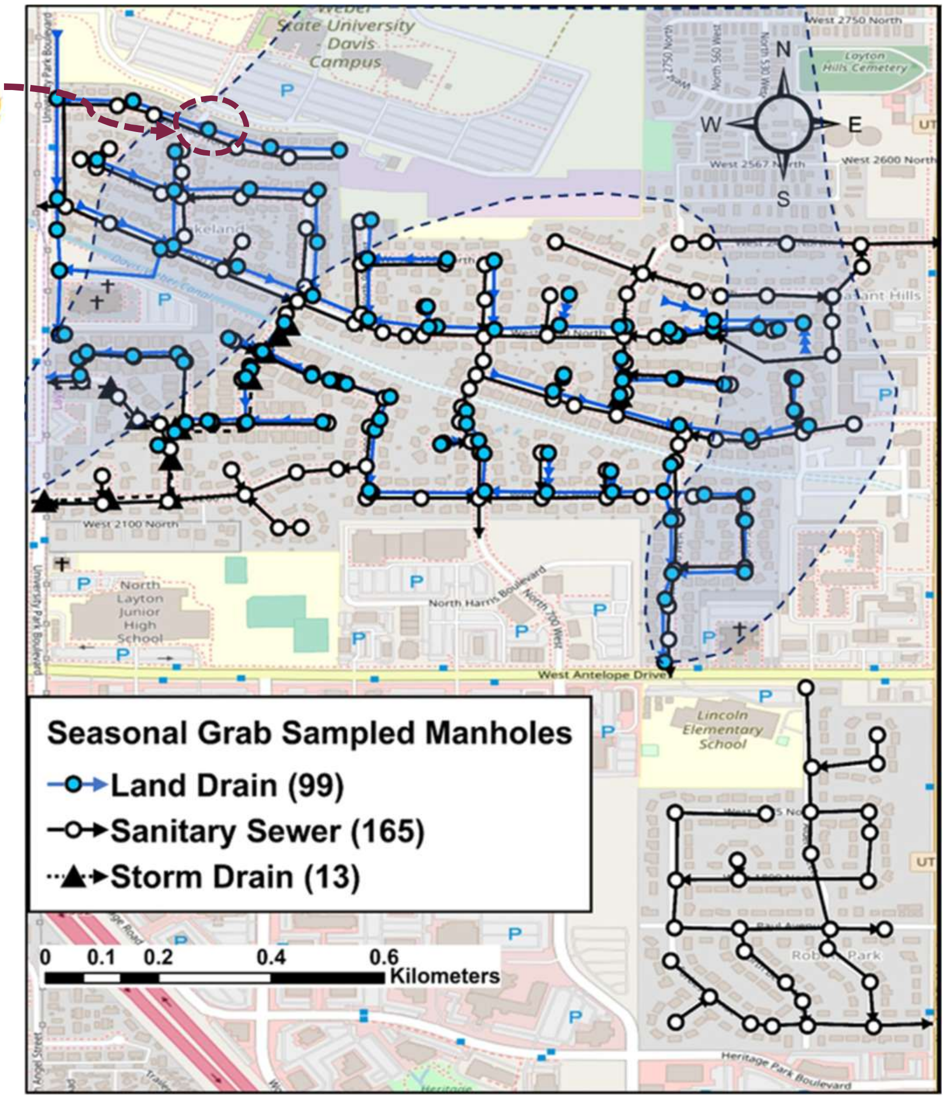
ESTCP ER-201501 (2015 – 2019)

ESTCP ER-201501

Objective:

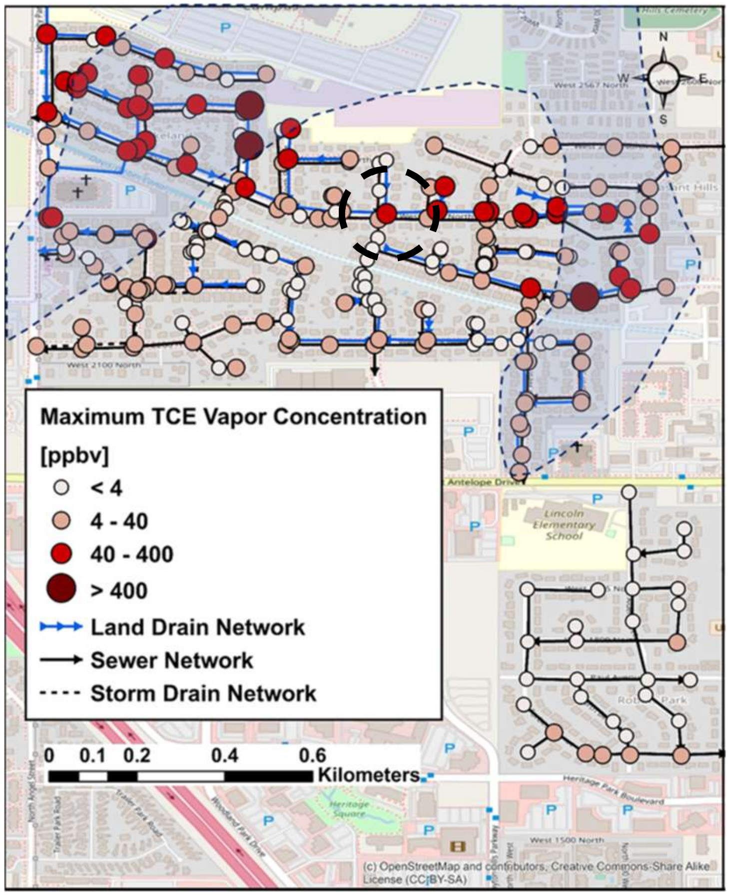
To demonstrate and validate practical field methods for identifying, characterizing, and mitigating vapor intrusion through sewer and land-drain utility systems at chlorinated-solvent sites

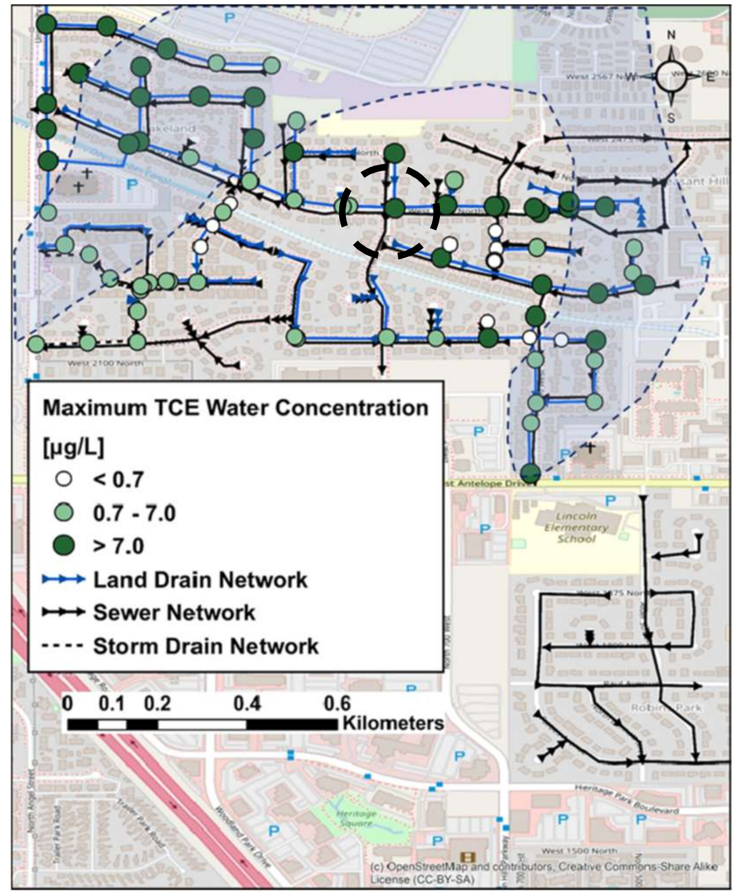
Field demonstration included focus on OU8 (i.e., neighborhood of Sun Devil Manor case study)



Adapted from Figure 2, Guo et al., 2020, *Science of the Total Environment*

OU8: Conduit Vapor and Water Grab Samples

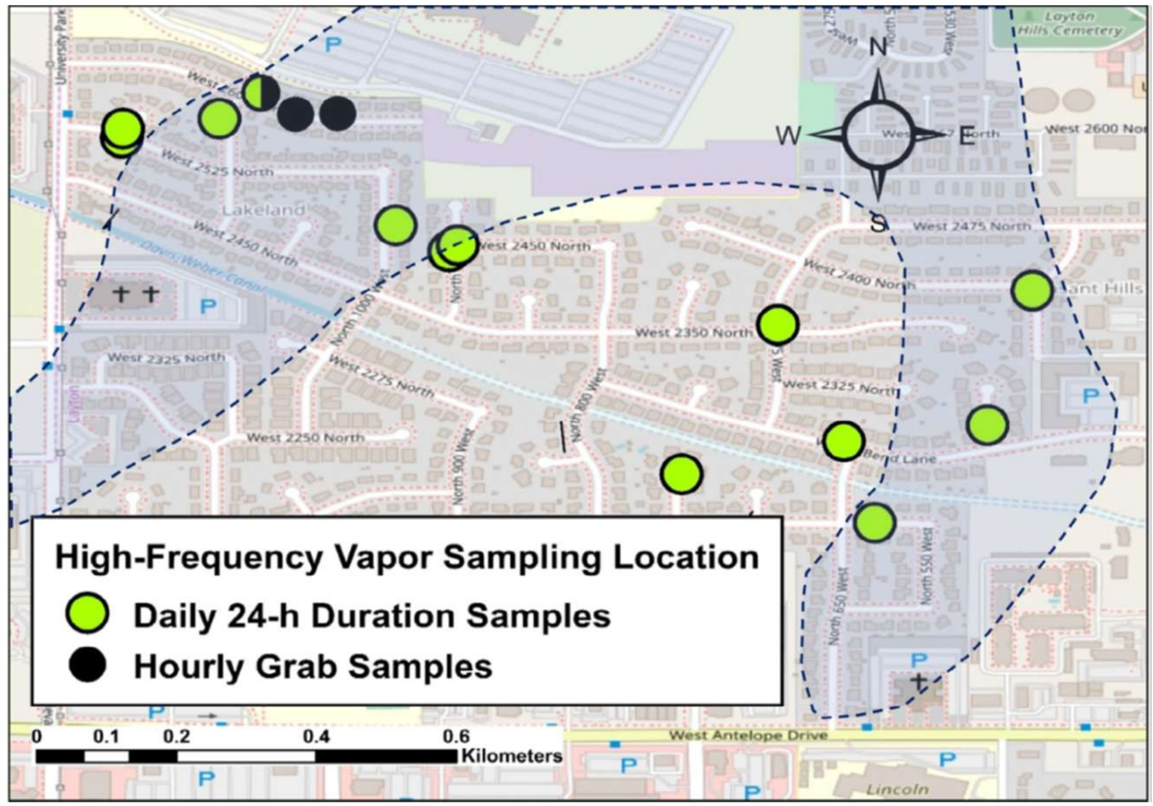




Adapted from Figures 4 and 5, Guo et al., 2020, *Science of the Total Environment*

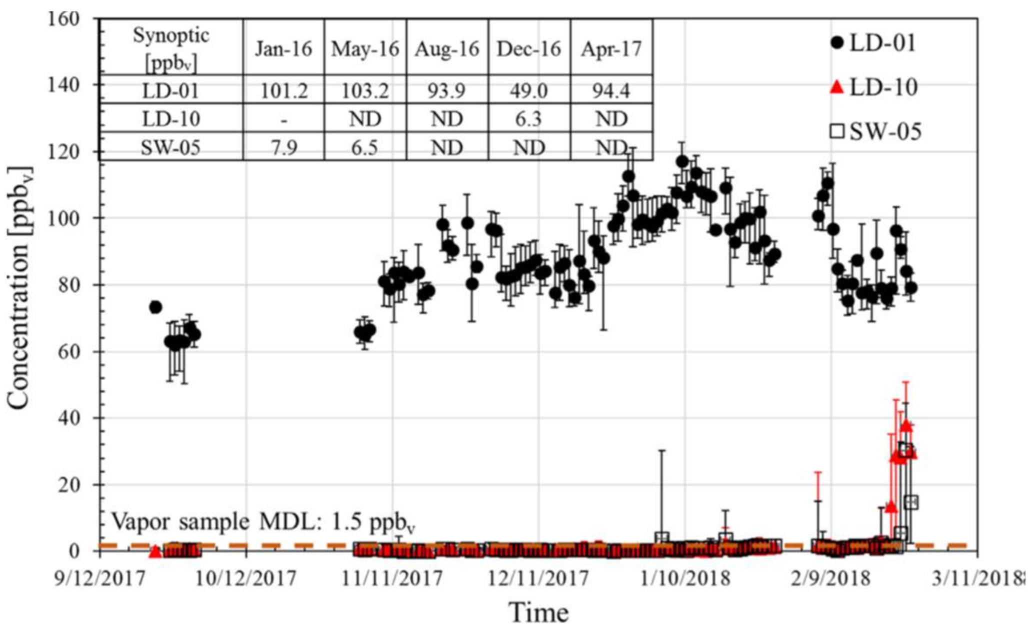
OU8: High-Frequency Conduit Vapor

Overview of high-frequency conduit vapor sampling approach

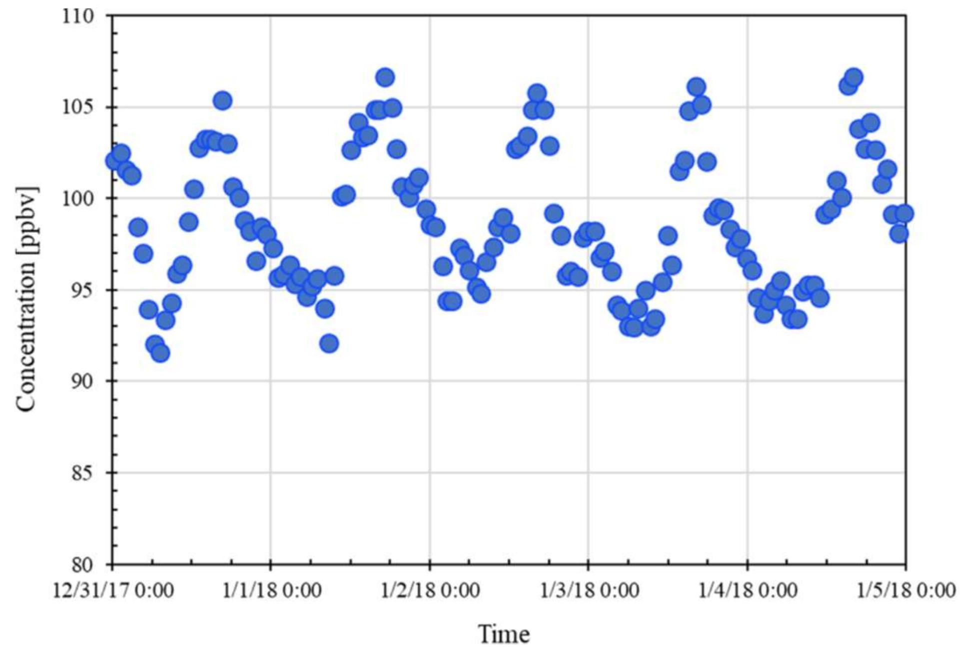


Adapted from Figure 3, Guo et al., 2020, *Science of the Total Environment*

OU8: High-Frequency Conduit Vapor



24-hour averaged manhole headspace TCE concentration



Hourly manhole headspace TCE concentration (LD-01)

Adapted from Figures 9 and 10, Guo et al., 2020, *Science of the Total Environment*

Active and Passive Sampling Comparison

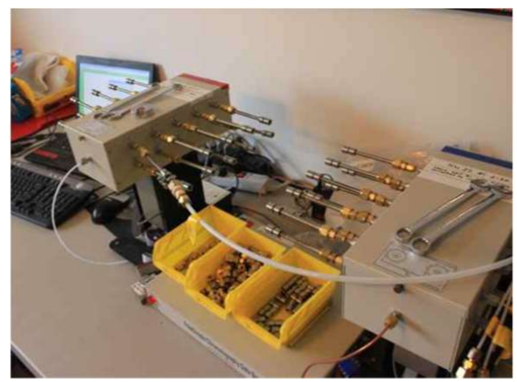


Image: ASU Research House, passive sampler comparison study, results published in Guo et al., 2021, *Groundwater Monitoring & Remediation*

Summary and Closing Thoughts

- Multiple technologies and feedback loops can help define long-term site management success.
- Long-term monitoring revealed key drivers of VI variability.
- Hill AFB provides a good example of long-term VI management through adaptive, data-driven stewardship.

Questions?

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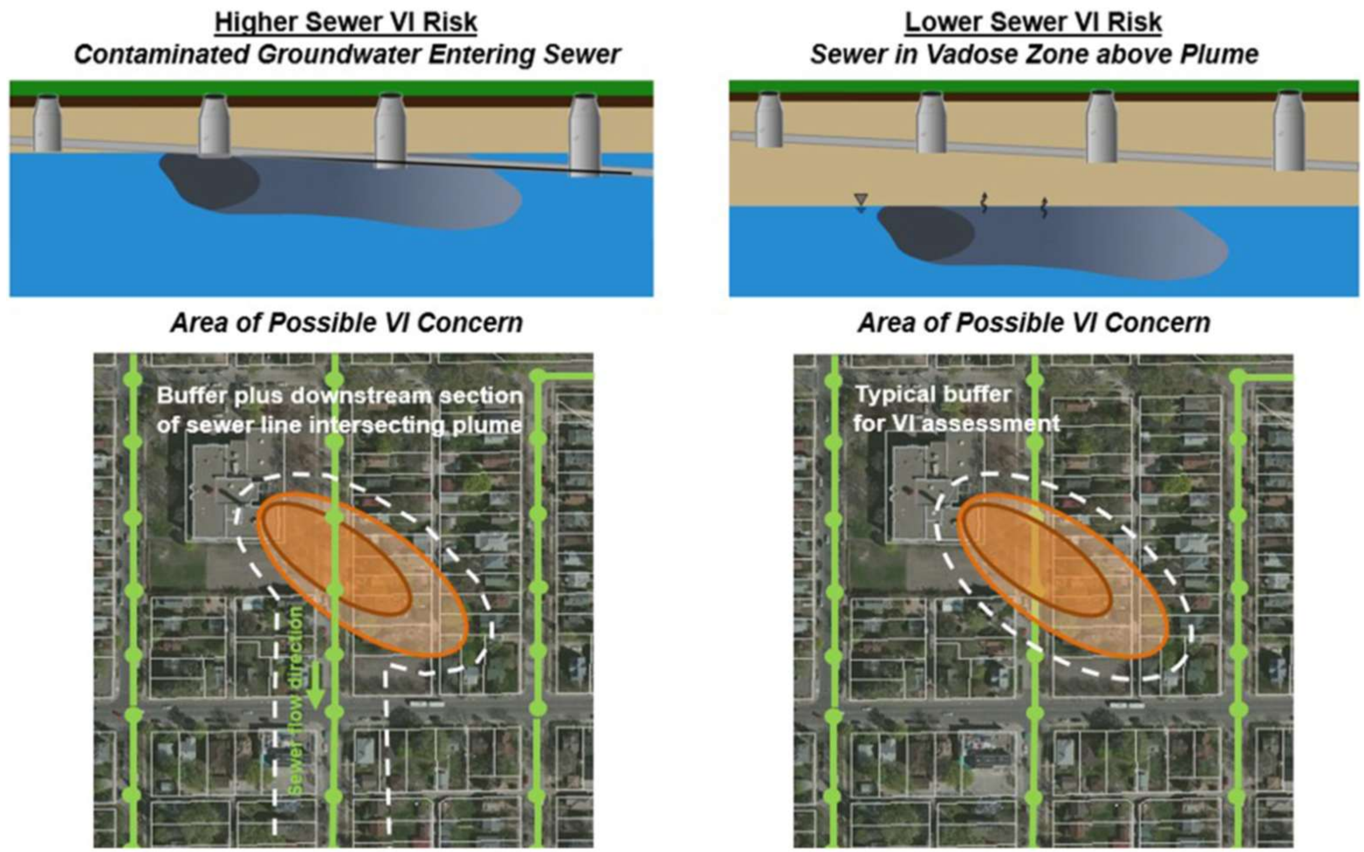
Sewer VI Scenarios

Higher and Lower Vapor Intrusion Risk Scenarios

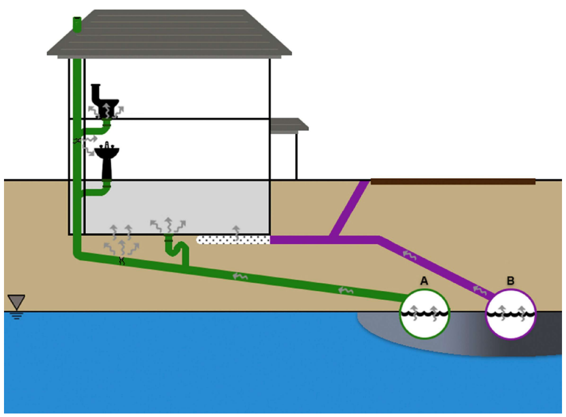


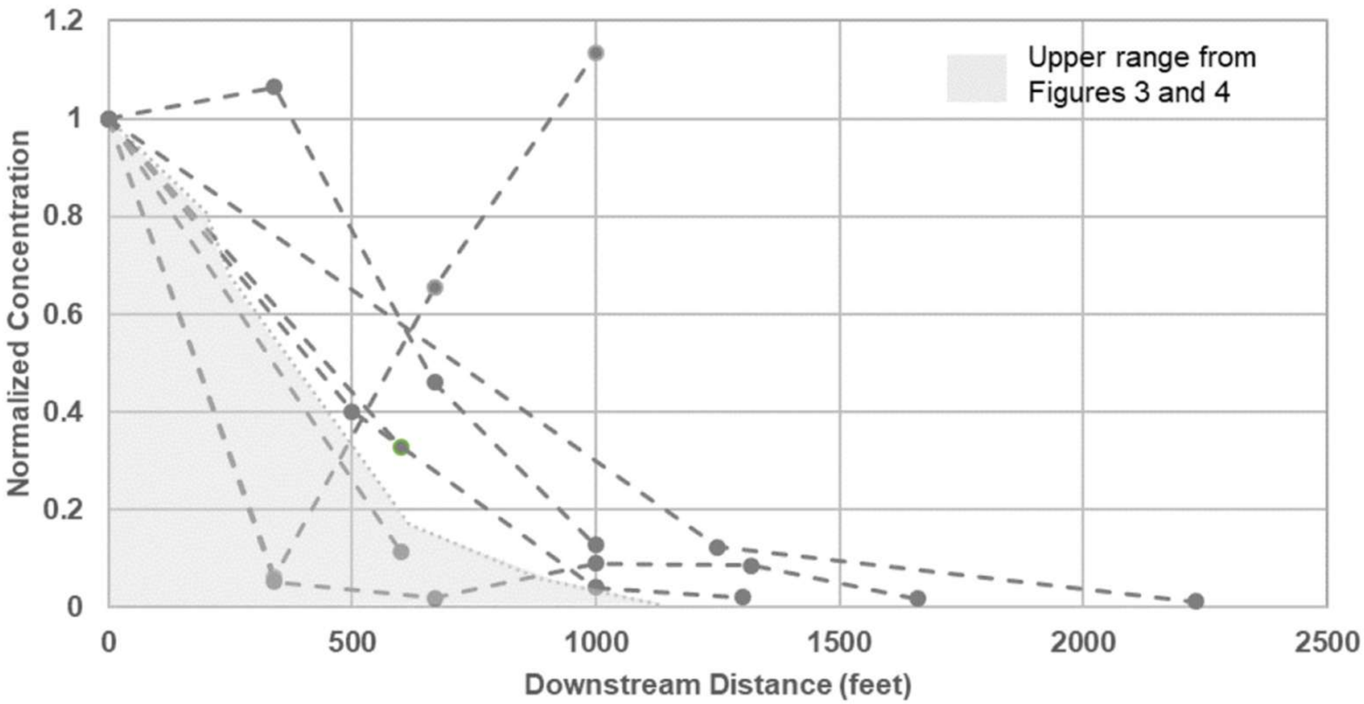
Reference: Figure 2, Beckley and McHugh, 2020, A conceptual model for vapor intrusion from groundwater through sewer lines, Science of the Total Environment, 698, 134283

Sewer Vapor Downstream Migration

Groundwater infiltration through sewer lines

(higher risk scenario)

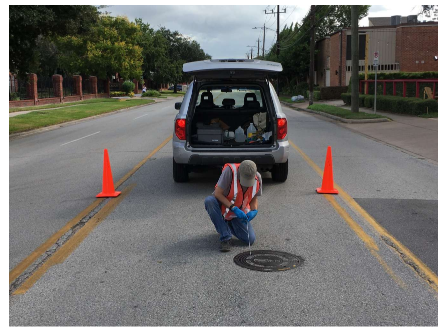


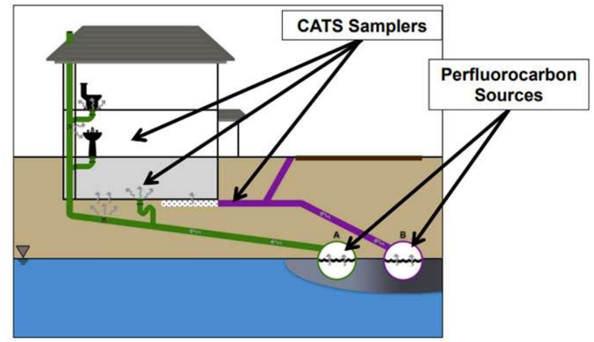


Reference: Beckley and McHugh, 2020, A conceptual model for vapor intrusion from groundwater through sewer lines, Science of the Total Environment, 698, 134283

Conduit Pathway Attenuation

Groundwater to sewer attenuation factors





Site category	No. plumes	No. AFs	Attenuation factor Median (10th – 90th percentiles) [Note 1]	Attenuation Median (10th – 90th percentiles) [Note 2]
A: direct interaction (sewer at or below water table)	6	59	1.3E−02 (6.7E−05–7.3E−02)	80× (15,000×–14×)
B: indirect interaction (sewer above water table)	28	137	1.3E−04 (1.9E−06–5.5E−03)	7900× (520,000×–180×)

Notes: 1) Attenuation factor calculated as sewer vapor concentration divided by equilibrium groundwater concentration. 2) Attenuation is the inverse of attenuation factor.

Reference: Beckley and McHugh, 2020, A conceptual model for vapor intrusion from groundwater through sewer lines, Science of the Total Environment, 698, 134283

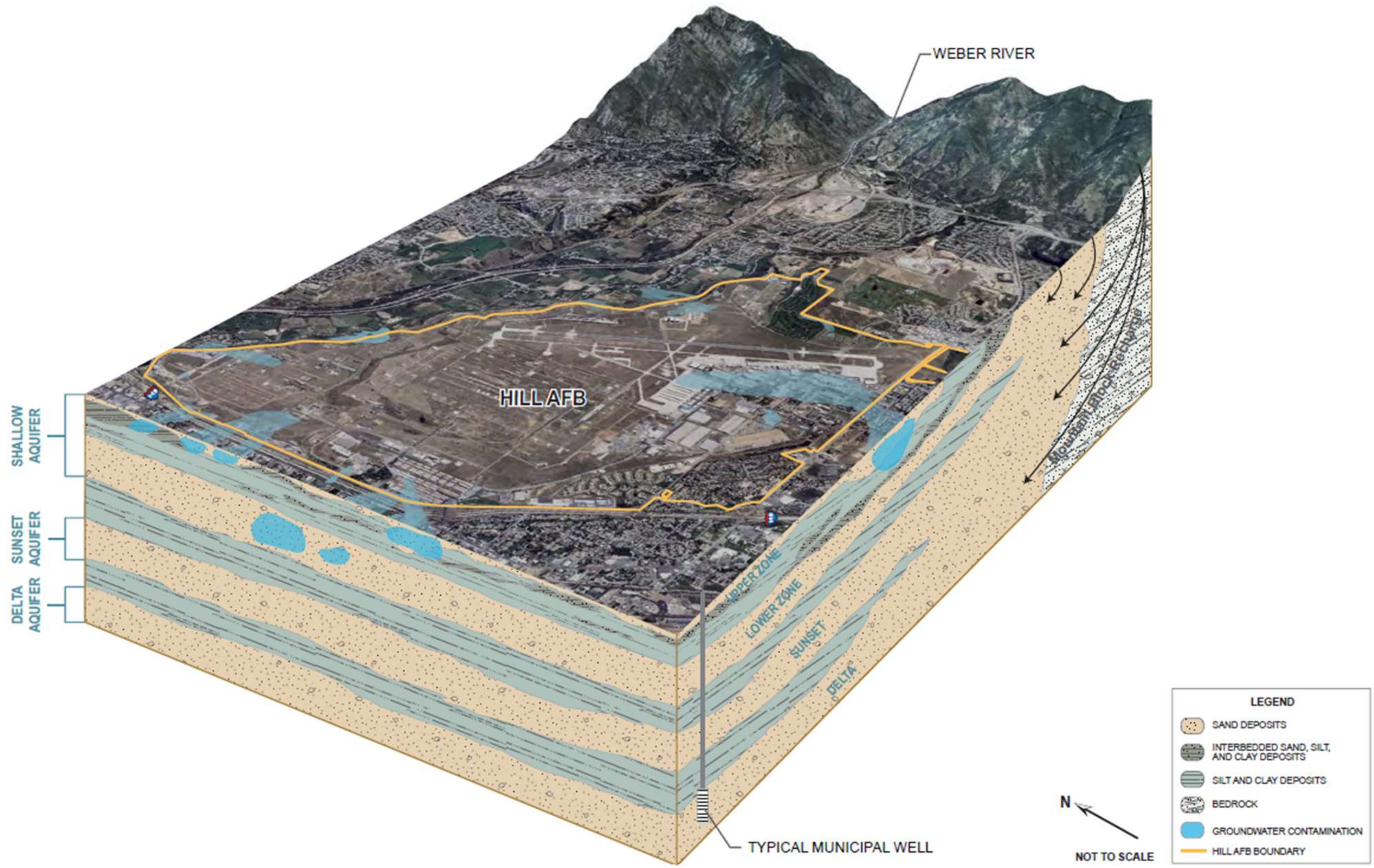
Conduit Pathway Attenuation – SDM

Groundwater to sewer attenuation factors:

ASU VI Research House, residential house, Layton, UT

Sewer/Building Combination Tested:	***Land Drain Manhole to House***	***Sanitary Sewer Manhole to House***
Attenuation	20x – 40x	60x – 80x

Reference: Beckley and McHugh, 2020, A conceptual model for vapor intrusion from groundwater through sewer lines, Science of the Total Environment, 698, 134283


WEBER RIVER
HILL AFB
SHALLOW AQUIFER
SUNSET AQUIFER
DELTA AQUIFER
UPPER ZONE
LOWER ZONE
SUNSET
DELTA
Mountain Block Recharge
TYPICAL MUNICIPAL WELL
N
NOT TO SCALE
LEGEND
SAND DEPOSITS
INTERBEDDED SAND, SILT, AND CLAY DEPOSITS
SILT AND CLAY DEPOSITS
BEDROCK
GROUNDWATER CONTAMINATION
HILL AFB BOUNDARY