Naval Facilities Engineering Command
ENGINEERING AND EXPEDITIONARY WARFARE CENTER

Open Environmental Restoration Resources (OER2)
Vapor Intrusion (VI): Tools and Technologies

Travis Lewis
(NAVFAC EXWC)

Logistics

- Submit all questions via “Ask A Question” throughout the presentation
- Presentation is being recorded
- Complete the webinar survey

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- Participation is voluntary and cannot be misconstrued as a new scope or growth of an existing scope under any contracts or task orders under NAVFAC

Speaker Introductions

Travis Lewis, PE
NAVFAC EXWC

Education:
- MS Civil & Environmental Engineer, Colorado School of Mines
- BS Chemistry, Hydrology, and Environmental Science, University of Arizona

Experience
- 10 years Environmental Consultant
- 5 Years NAVFAC EXWC, EV31 (Env. Restoration)
- Engineering Duty Officer (US Navy Reserves)

Applicable VI Research
- NESDI 554 – VI Temporal Variability (2017 – 2020)
- NESDI 568 – VI Real-Time Samplers (ongoing)
- NESDI 571 – HVAC Filters for VI Rapid Response (ongoing)

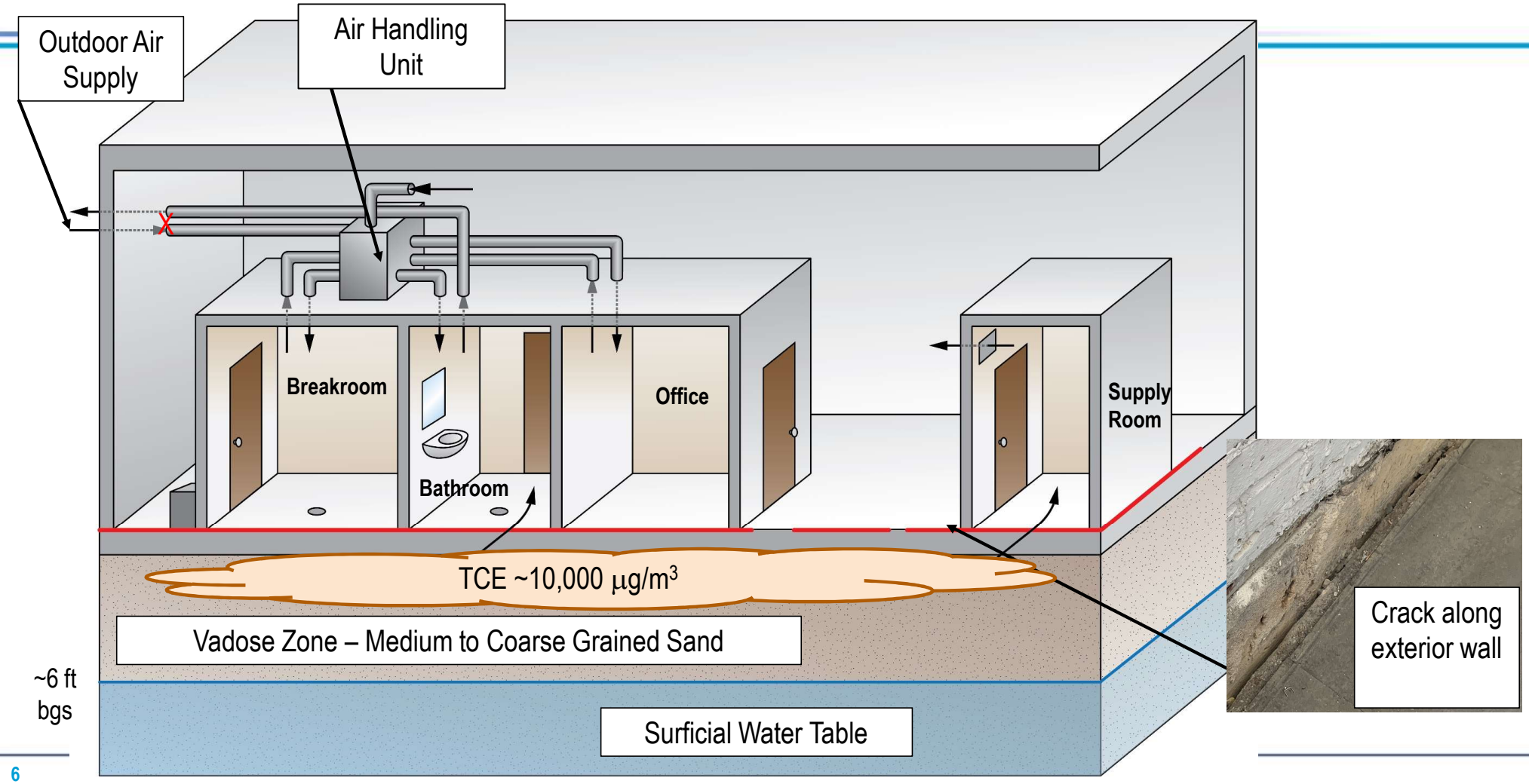
OER2 Webinar Series

- Why Attend?
  - Hear about the latest DOD and DON's policies/guidance, tools, technologies and practices to improve the ERP's efficiency
  - Promote innovation and share lessons learned
  - FEEDBACK to the ERP Leadership
- Who Should Attend?
  - ERP Community Members: RPMs, RTMs, Contractors, and other remediation practitioners who support and execute the ERP
  - Voluntary participation
- Schedule:
  - Quarterly webinars
- Topics and Presenters:
  - ERP community members to submit topics (non-marketing and DON ERP-relevant) to POCs (Gunarti Coghlan – gunarti.coghlan@navy.mil or Amy Hawkins – amy.hawkins@navy.mil)
  - Selected topic will be assigned Champion to work with presenter

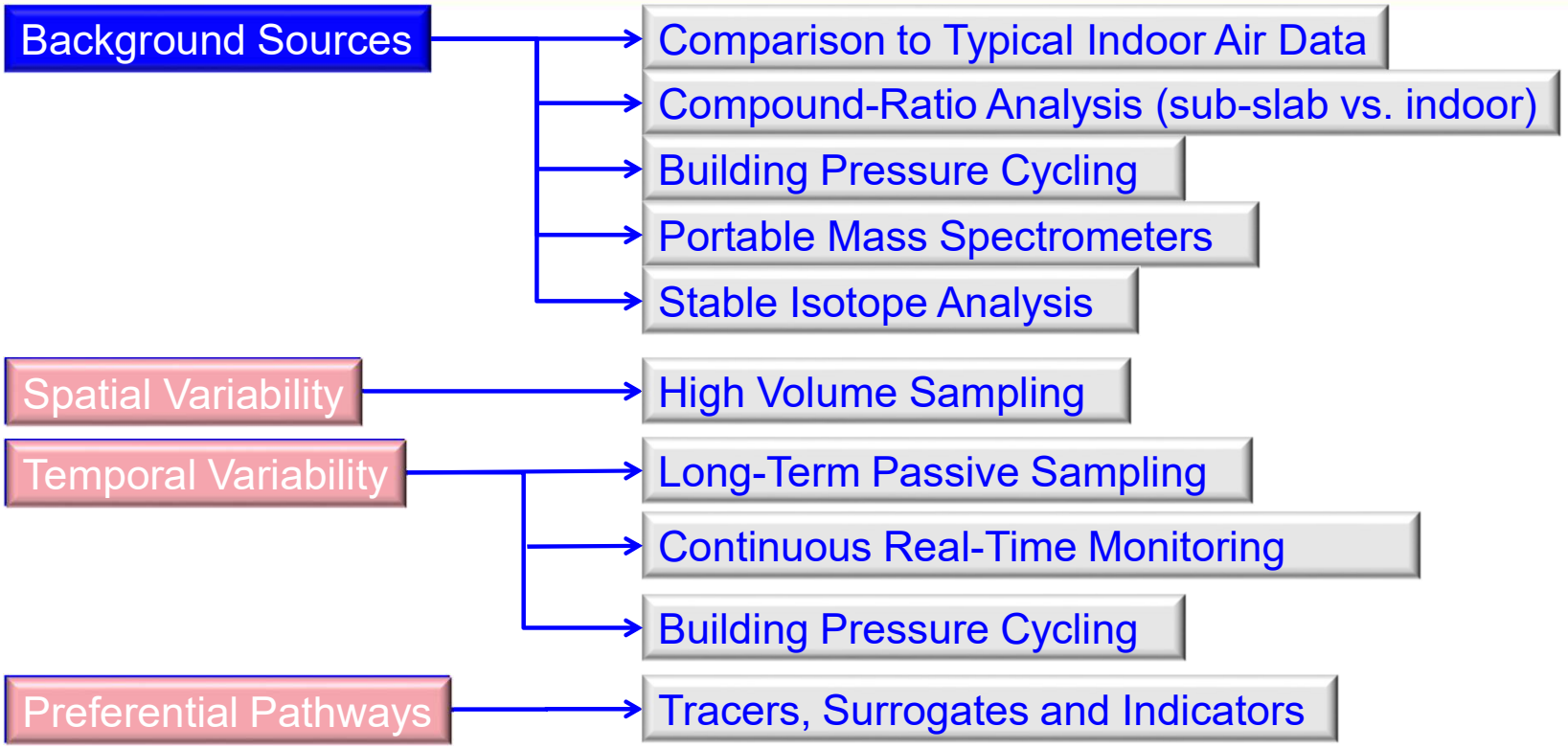
Presentation Overview

- Introduction
- Continuous Real-Time Monitoring – GC/ECD
- Tracers, Surrogates, and Indicators
- Building Pressure Cycling
- High Volume Sampling
- Wrap-Up

Vapor Intrusion Conceptual Site Model



There is a Solution for Every Challenge



Key Point Customize the lines of evidence to the site-specific or building-specific challenge(s)

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Continuous Real-Time Monitoring – GC/ECD

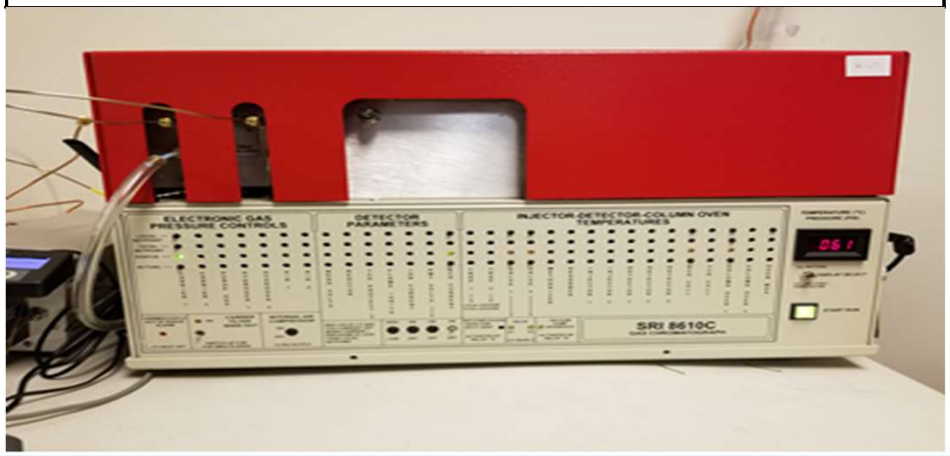
- **Transportable GC/ECD**
  - Able to collect and analyze several compounds simultaneously from various building units using multiple sample port (20-50 ports)
- **Advantages**
  - Supports real-time decisions
  - Understand cause-and-effect relationships for better CSM
  - Rapid data interpretations can save time and money
  - Line of evidence to validate data integrity
- **Limitations**
  - Cost (GC/ECD unit, labor/material for tubing install, calibration, interpretation)
  - Sensitivity issues with concurrently collecting sub-slab and IA samples
  - Generally not useful for petroleum compounds
  - Linear relationship between elution time and number of sampling ports (runtime 10 min or more depending on the compound of interest)

DoD Vapor Intrusion Handbook
Fact Sheet Update No: 002
Date: February 2017

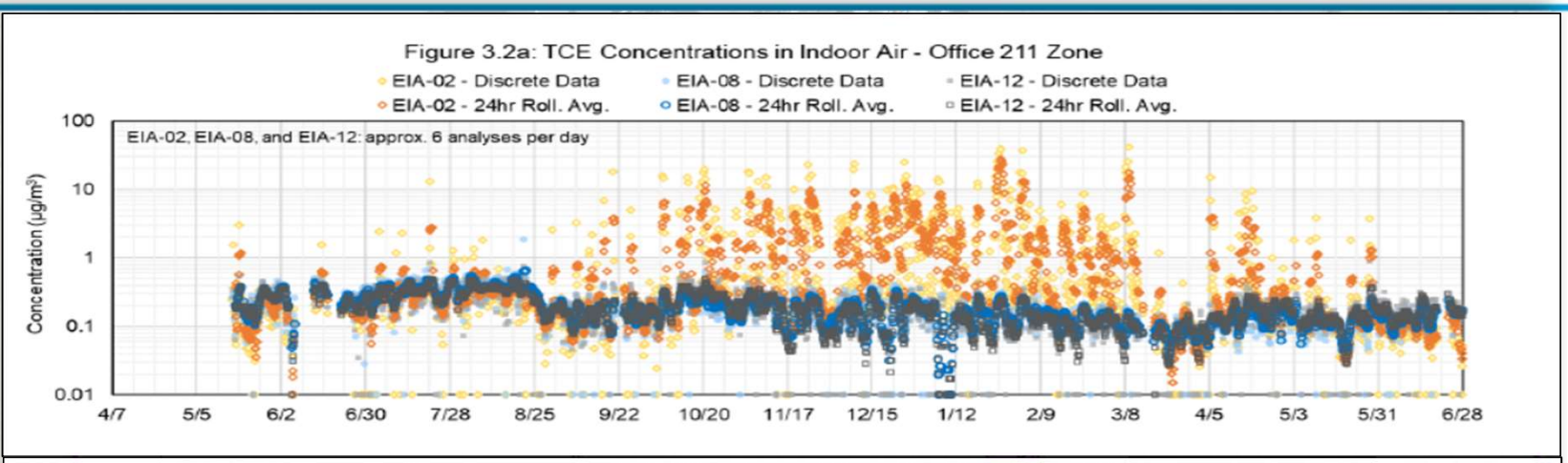
Real-Time Monitoring for Vapor Intrusion Assessment

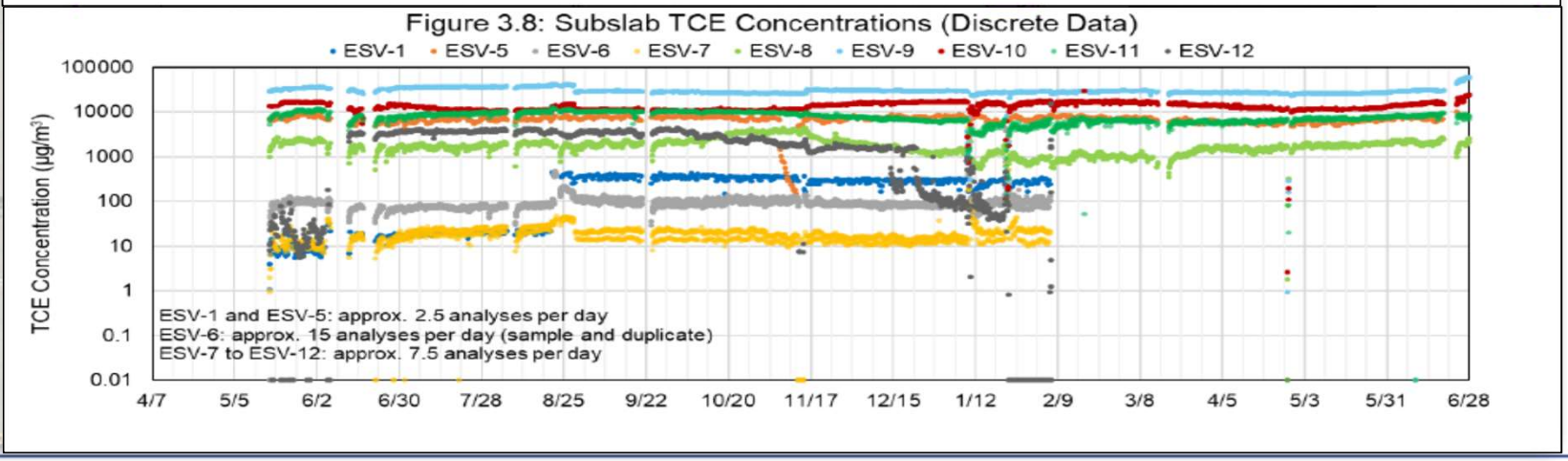
Purpose

This fact sheet prepared by the Department of Defense (DoD) Tri-Services Environmental Risk Assessment Workgroup (TSERAWG) relates to Sections 2, 3, and Appendix D of the DoD Vapor Intrusion Handbook, and reflects application of new technologies for vapor intrusion sampling.



GC/ECD – NESDI 554 NAS Norfolk





- IA concentrations varied temporally by ~2 orders of magnitude (as 24-hour rolling average concentrations) in the zones where the VI pathway was locally complete.
- SSSG concentrations varied spatially by ~4 orders of magnitude but showed relatively little temporal variability.

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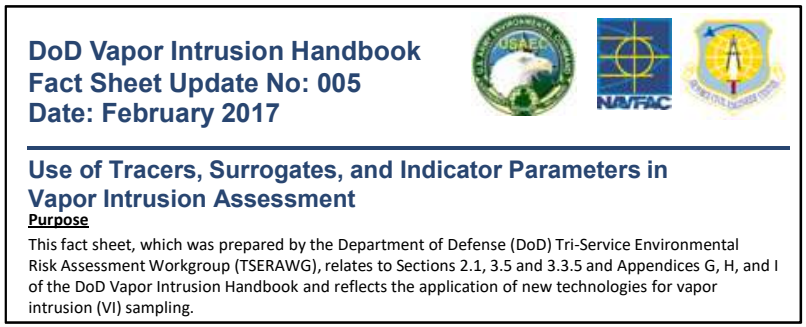
Tracers, Surrogates, and Indicators

- **Tracers mimic VOC VI migration**
  - SF6, Helium
  - Release tracers in subsurface or preferential pathways (sewer pipes) and monitor indoor air
- **Surrogates substitute for VI VOC**
  - Radon indoor air subslab ratio to estimate slab attenuation
  - VOCs (e.g., 1,1-DCE, cis-1,2-DCE) not commonly found in background
- **Indicators of potential VI exposures**
  - Building pressure/temperature
  - Subslab PID/FID screen

- **Advantages**
  - Reduced potential for low-biased exposure estimates
  - Used to demonstrate VI mitigation system performance
  - Provides information on temporal variability
- **Limitations**
  - Correlation between indicators and VI may require costly effort to characterize building
  - Correlation varies by place and time



DoD Vapor Intrusion Handbook
Fact Sheet Update No: 005
Date: February 2017

Use of Tracers, Surrogates, and Indicator Parameters in Vapor Intrusion Assessment

Purpose

This fact sheet, which was prepared by the Department of Defense (DoD) Tri-Service Environmental Risk Assessment Workgroup (TSERAWG), relates to Sections 2.1, 3.5 and 3.3.5 and Appendices G, H, and I of the DoD Vapor Intrusion Handbook and reflects the application of new technologies for vapor intrusion (VI) sampling.

Surrogate and Indicator – Radon & Differential Pressure (NESDI 554)

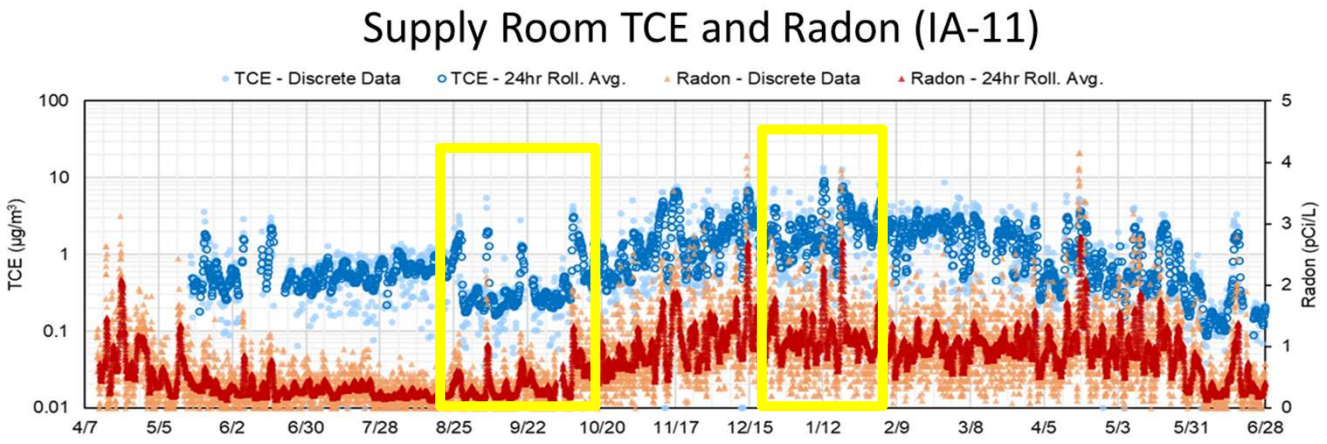
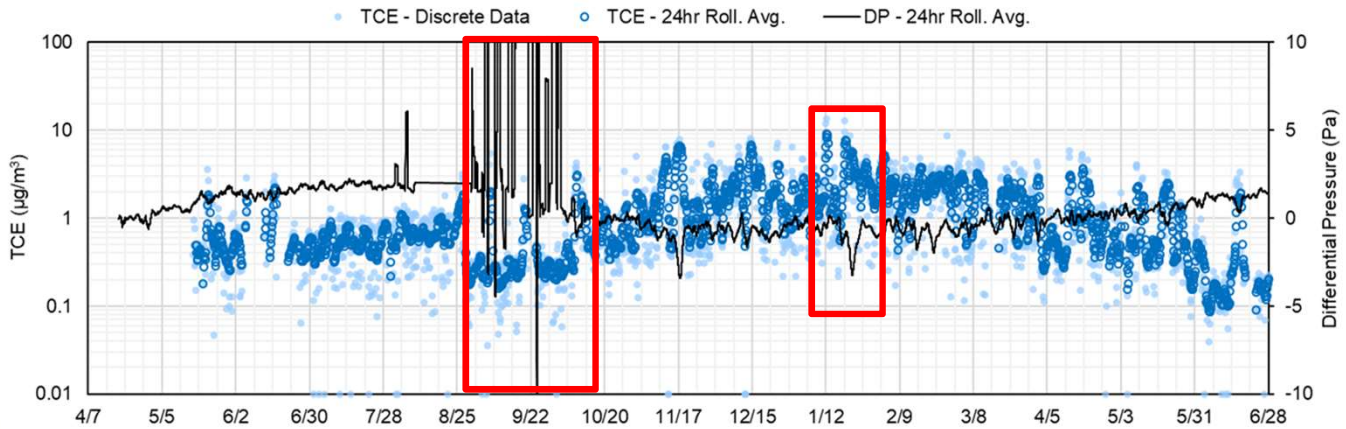


Figure 3.64b: TCE and Indoor-to-Subslab Differential Pressure - Supply Room 210 Zone



- Indoor radon can be used as a surrogate for predicting periods of relatively elevated TCE concentrations in indoor air.
- Radon may be a better indicator in zones where air exchange is lower.

Higher TCE generally associated with more negative differential pressure during the winter season (heating/stack effect)

Air Exchange Rate – SF6 Tracer Testing (NESDI 554)

- HVAC/Sampling Zones initially identified through a visual- and interview
- Tracer Testing (SF_6 decay) to determine baseline AER

Space Tested	Test Date (2019)	Room Volume (Cubic Feet)	Ventilation		Notes
			ACH	CFM	
Zone 1	3/27	9,450	0.80	126	—
Zone 2 Office	3/27	4,186	2.99	208	Outside air damper open
Zone 2 —Breakroom	3/27	4,078	2.96	202	Outside air damper open
Zone 2—Men's Restroom	3/28	1,569	3.08	81	Outside air damper open, door opened 14 times
Zone 2— Breakroom	3/28	4,078	2.34	159	Outside air damper closed
Zone 2 — Office	3/28	4,186	2.71	189	Outside air damper closed, door opened 6 times
Zone 2—Men's Restroom	3/28	1,569	3.06	80	Outside air damper closed, door opened 10 times
Zone 3	3/27	5,720	0.90	86	—
Zone 4	3/27	5,870	0.21	21	—

- AER: Air Exchange Rate
- ACH: Air Changes per Hour (i.e. Turnover)
- CFM: Cubic Feet per Minute

- AER in Zone 2 (Breakroom/Restrooms) ~ 15 times higher than Zone 4 (Supply Room)
- Data suggest radon is more effective in predicting VI in sampling zones with low AER, where radon intrusion is more likely to result in measurable indoor radon concentrations relative to the outdoor.

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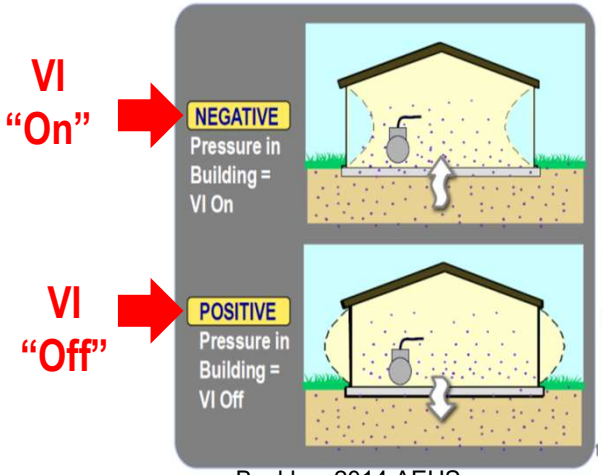
Building Pressure Cycling

- Depressurize building and VI is “turned on”
- Can estimate near worst case exposures within hours
- Screen for vapor entry points under negative pressures
- **Advantages**
  - Concentrations measured in controlled pressure conditions
  - Cost-effective since testing is completed in one event
- **Limitations**
  - Not suitable for large leaky buildings



Beckley, 2014 AEHS

Key Points

- **Measure building pressure under natural conditions, don’t exceed typical vacuum range**
- **Flush several building volumes before sampling**

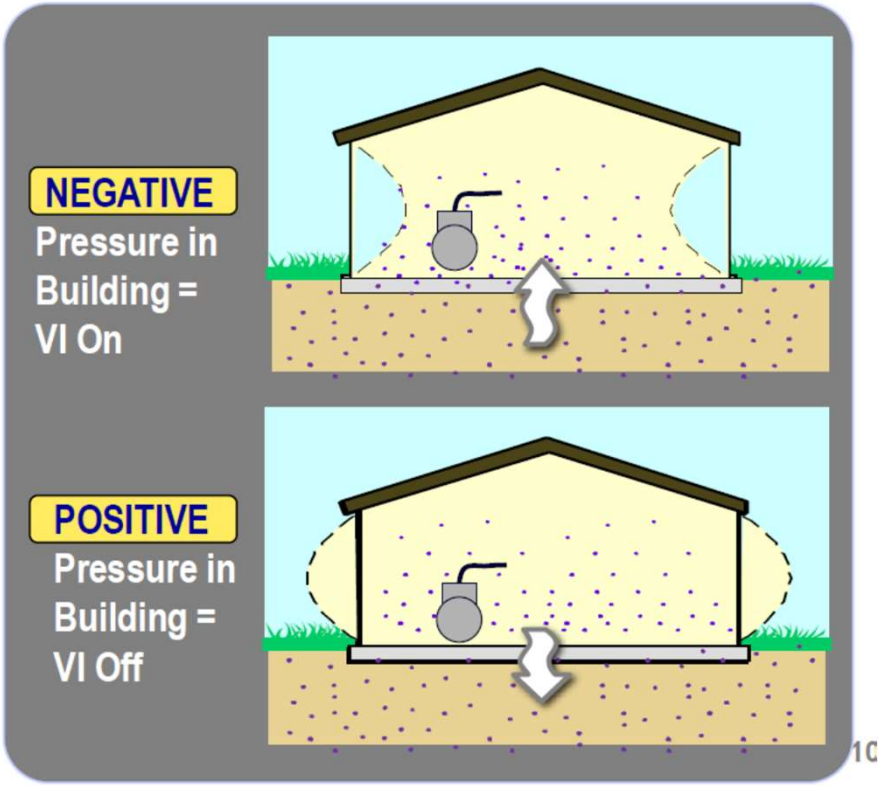
DoD Vapor Intrusion Handbook
Fact Sheet Update No: 004
Date: February 2017

Use of Building Pressure Cycling in Vapor Intrusion Assessment

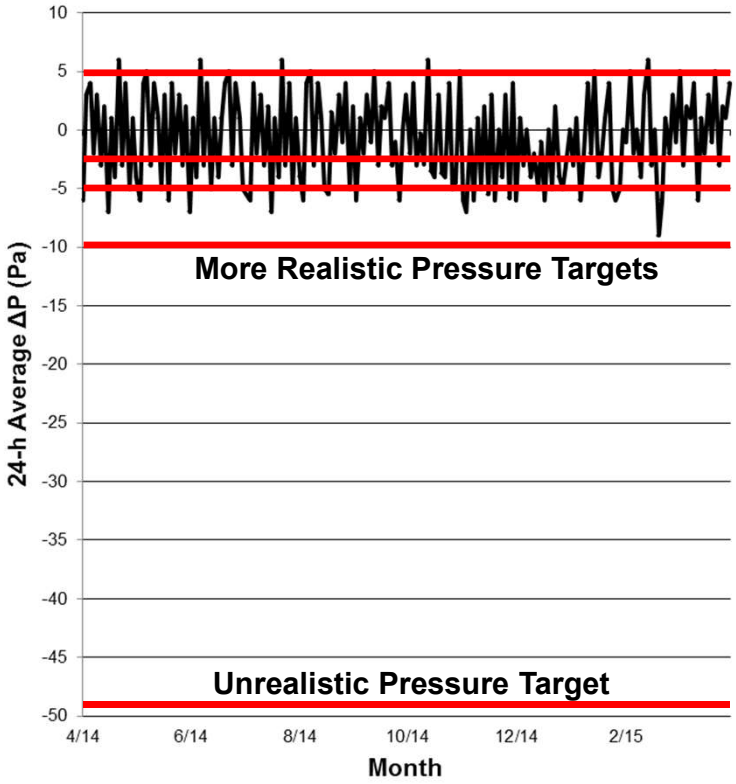
Purpose

This fact sheet relates to Sections 2.7, 2.8, 3.34, 3.5 and Appendix G of the DoD Vapor Intrusion Handbook. These sections describe methods for indoor air sampling and determining the influence of background sources. Building pressure cycling (BPC) offers an alternative approach to the methods described in the Handbook.

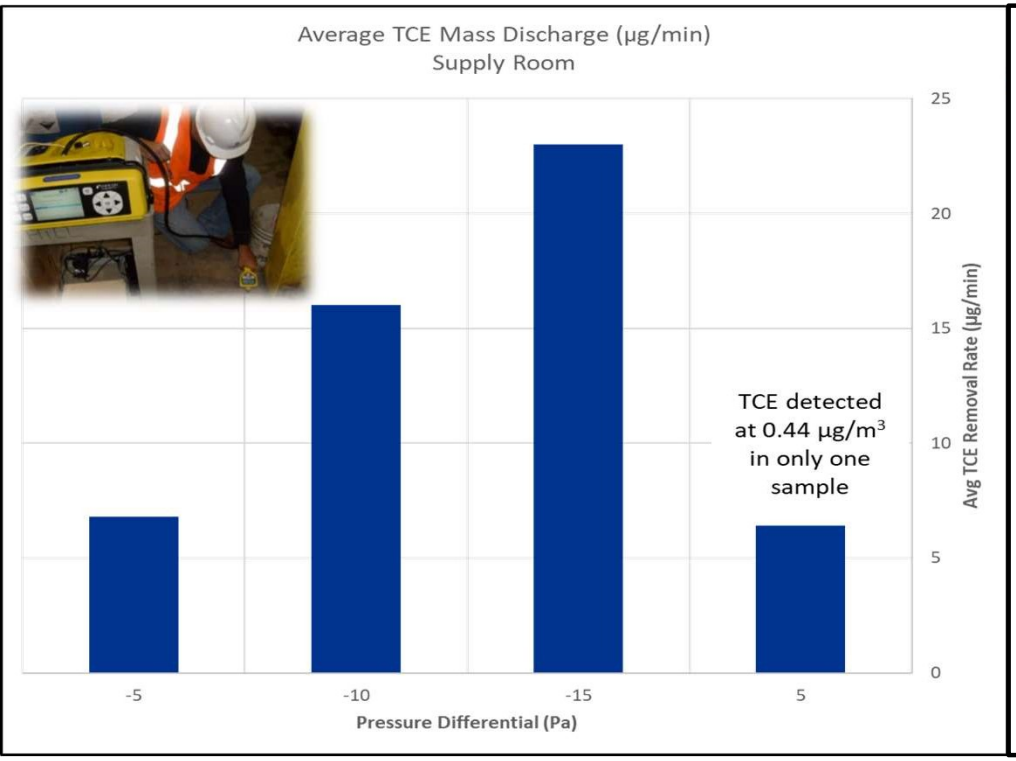
Solution for Background Sources: Building Pressure Cycling

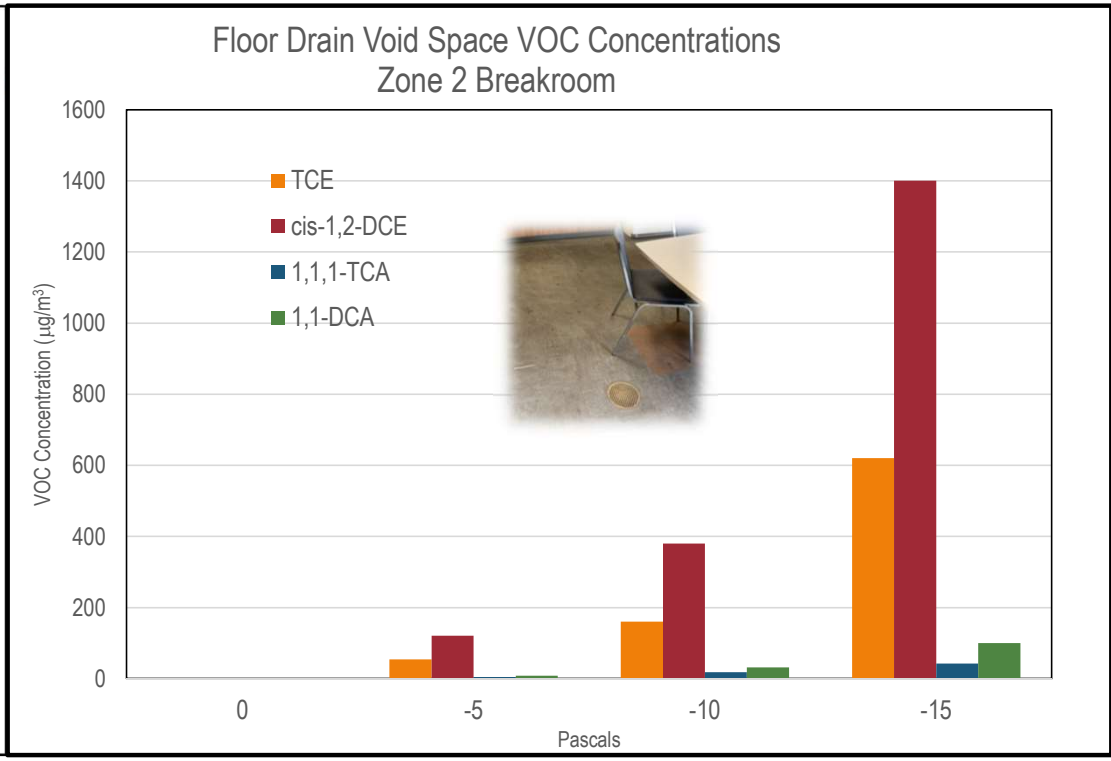


Beckley, 2014 AEHS



HAPSITE Survey and Pressure Cycling (NESDI 554)





- Indicates VI is occurring
  - Increasing Mass Discharge under increasingly negative conditions
  - Decrease in Mass Discharge under positive conditions

- Potential preferential pathway identified during building survey (floor drain)
  - Samples collected with HAPSITE indicate increasing trend in void space during negative pressure tests

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High Volume Sampling

- Assess soil gas concentration, distribution, and slab attenuation
  - Remove large volume soil gas and monitor response
- **Advantages**
  - Fewer locations to assess large areas saving time and money
  - Less chance of missing subslab hotspot area
  - Assess soil gas in areas not accessible for subslab port installation
  - Aid in identifying atypical preferential pathway
  - Data for optimal subslab venting system design
- **Limitations**
  - Clay-rich or wet soils can yield low flow rates
  - Manage discharge and/or treatment of extracted volume of soil gas
  - Greater equipment requirements than conventional subslab sampling
  - Disruption to occupants greater than conventional subslab sampling

DoD Vapor Intrusion Handbook
Fact Sheet Update No: 003
Date: February 2017

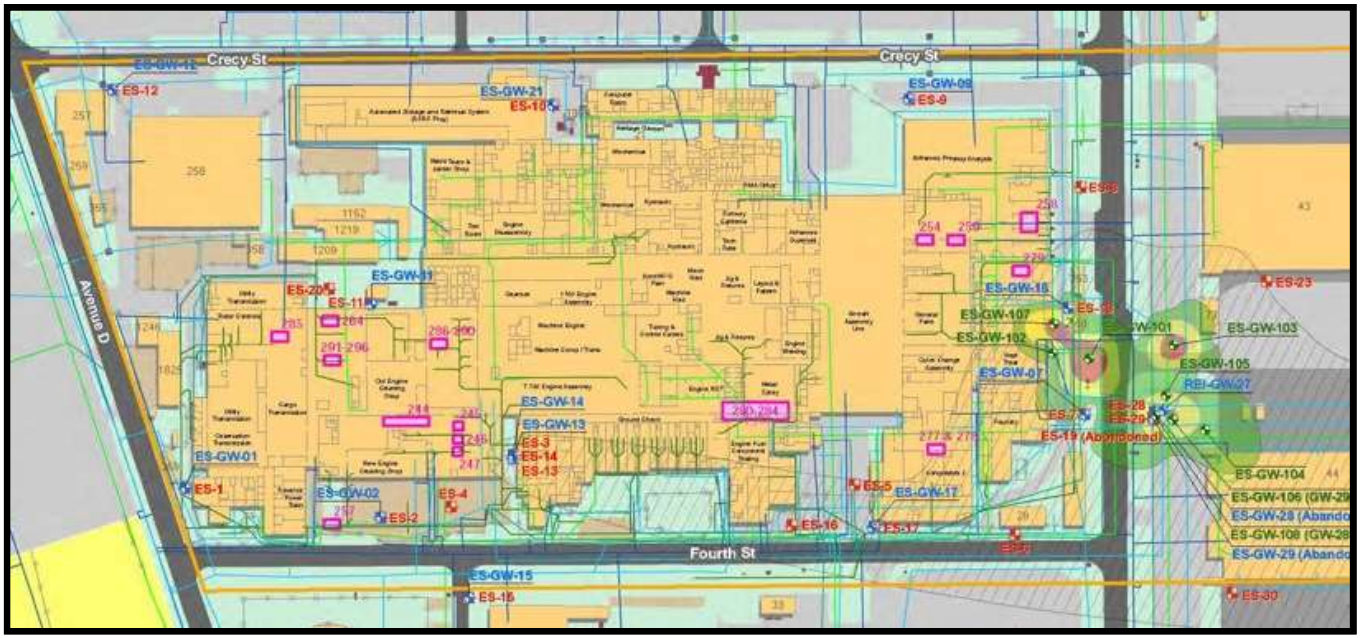
High Volume Soil Gas Sampling for Vapor Intrusion Assessment

Purpose
This fact sheet prepared by the Department of Defense (DoD) Tri-Services Environmental Risk Assessment Workgroup (TSERAWG) relates to Sections 3.3.3 and Appendix D of the DoD Vapor Intrusion Handbook, and reflects application of new technologies for vapor intrusion sampling.

Key Point Excellent tool for addressing spatial variability

High Volume Sampling Case Study: Corpus Christi Army Depot

- Army tenant; Navy property
- 1,000,000 ft^2 (~20-acre) helicopter maintenance building
- Not feasible to pincushion with subslab samples



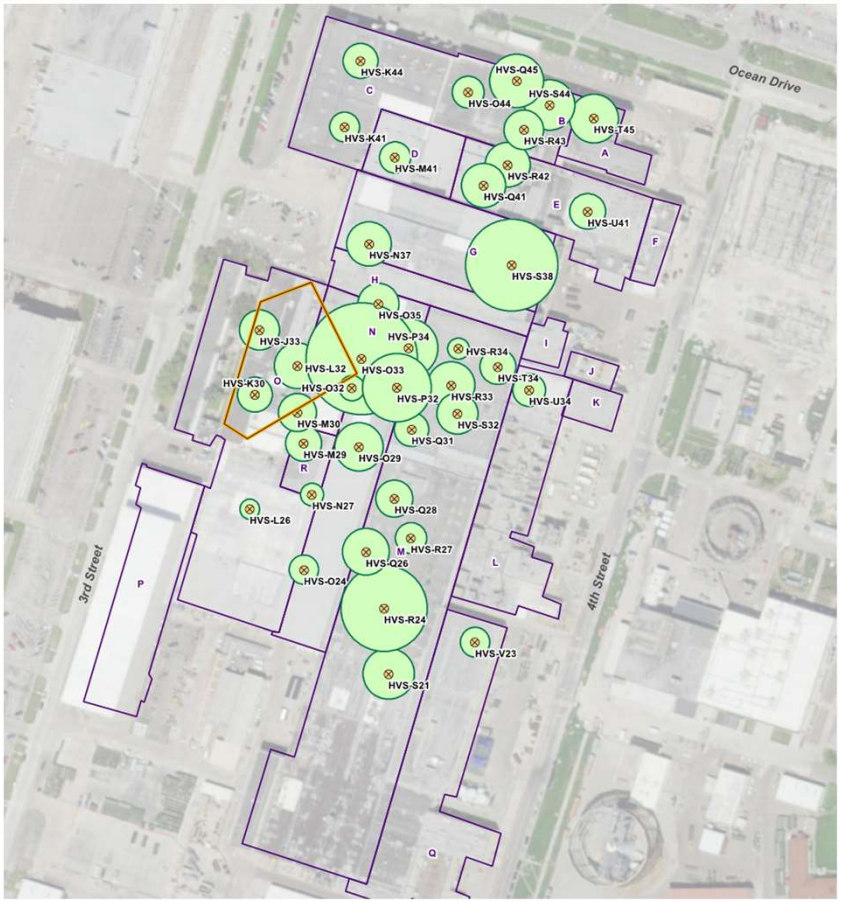
High Volume Sampling Case Study: Corpus Christi Army Depot (cont.)

- Simple layout
- 3-in.-Diameter High Volume Suction Point
- Subslab Observation Ports

Courtesy of Geosyntec

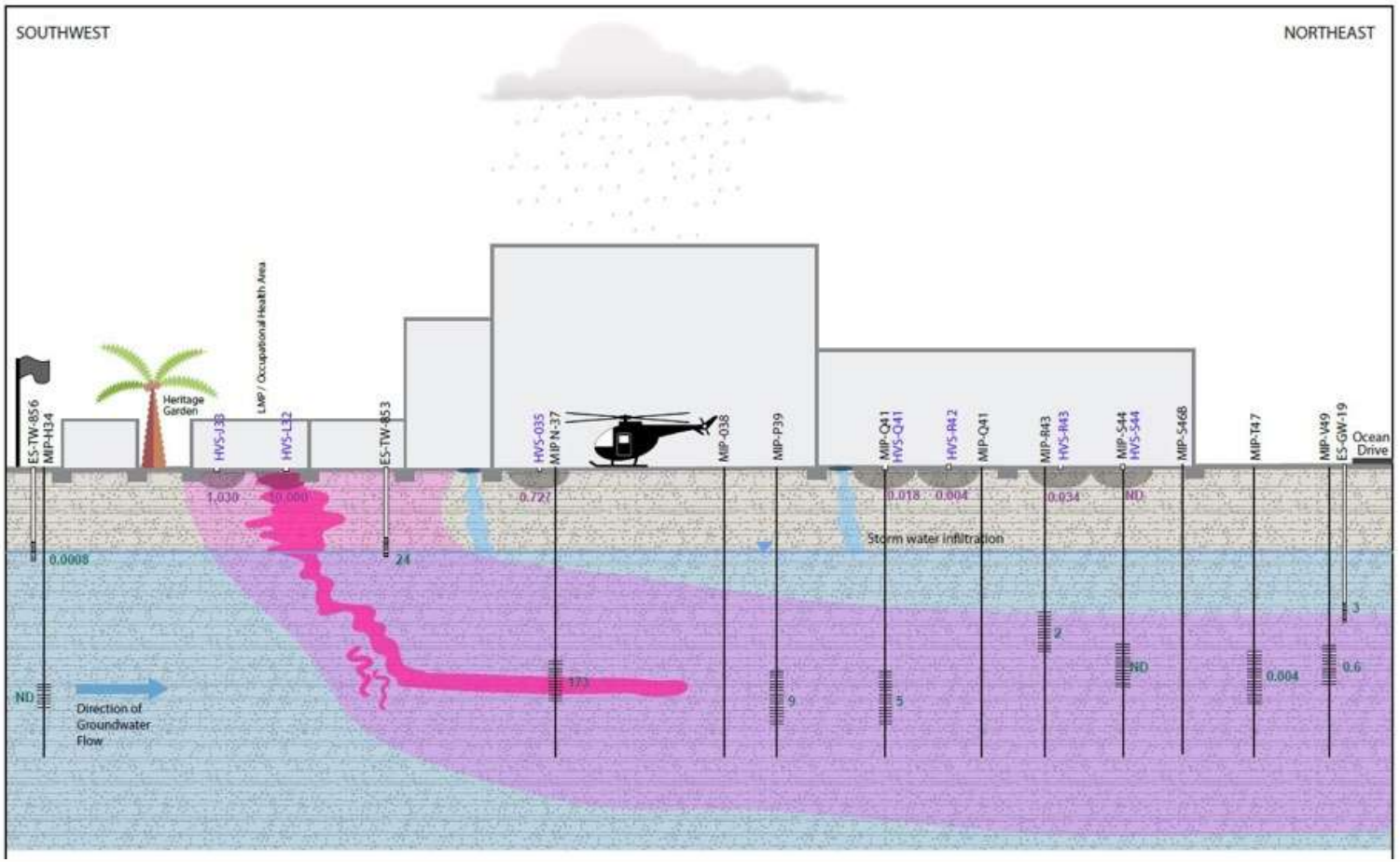
High Volume Sampling Case Study: Corpus Christi Army Depot (cont.)

- HVS with real time samples allowed identification of only 1 acre area of soil vapor source
- Groundwater and HVS data confirm clean water lens
- HVS provides data for design of soil vapor mitigation system



High Volume Sampling Case Study: Corpus Christi Army Depot (cont.)

- Revised CSM



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Wrap-Up

Temporal Variability

Continuous Real-Time Monitoring

- Able to collect and analyze several compounds simultaneously (20-50 ports)
- High costs associated with the equipment/setup, requires dedicated space, and sensitivity issue with IA/sub-slab co-locations.

Building Pressure Cycling

- Can estimate near worst case exposures within hours
- Pressure settings need to mimic normal operating conditions
- Challenging in large industrial warehouse settings.

Preferential Pathways

Tracers, Surrogates and Indicators

- Can be used to mimic VI migration and assess potential for exposure
- Measureable Radon is a excellent surrogate for identifying subsurface VI exposure (better in low AER situations)
- VI conditions are more likely in negative pressure settings (i.e. heating)

Spatial Variability

High Volume Sampling

- Remove large volume soil gas and monitor response
- Excellent for measuring spatial variability/ accessing challenging areas
- Need to manage extracted soil gas

Resources and References

- Navy ER Website
  - https://www.navfac.navy.mil/go/erb
- DENIX IRP Website
  - http://www.denix.osd.mil/irp/navyvaporresources/
- Fact Sheets for Emerging Technologies
  - http://www.denix.osd.mil/irp/vaporintrusion/
- USEPA OSWER VI Website
  - https://www.epa.gov/vaporintrusion
- Compilation of State Guidance
  - https://www.geosyntec.com/vapor-intrusion-guidance
- USEPA Clu-In VI Website
  - https://clu-in.org/issues/default.focus/sec/Vapor_Intrusion/cat/Overview/
- QDF Framework NESDI #476
  - https://clu-in.org/download/issues/vi/TR-NAVFAC-EXWC-EV-1603.pdf

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Questions and Answers

NAVFAC Points of Contact

- Travis Lewis (NAVFAC EXWC)
  - (805) 982-4454
  - travis.b.lewis@navy.mil
- Teresie Walker (LANT)
  - (757) 322-4699
  - teresie.walker@navy.mil

Wrap Up

Please complete the short, three question, feedback questionnaire. Links for NMCI and non-NMCI access are announced in the Q&A box.

Next OER2:

Environmental Sequence Stratigraphy

Coming May 2021

Thank you for participating!