ERDC/CRREL MP-22-4

Cold Regions Research and Engineering Laboratory

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VI Preferential Pathways of a Large Government Building

Jay Clausen. D. Moore, K. Miller, and L. Haines-Ecklund

February 2022

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Final report

Prepared for U.S. Army Environmental Command
Fort Sam Houston, TX 78234

Under MIPR Customer Order 11415853

Preface

This study was conducted for the U.S. Army Corps of Engineers (USACE) under IMCOM-WEST, Fort Sam Houston, MIPR Customer Order 11415853. The technical monitor was Dr. Jay Clausen.

The work was performed by the Biogeochemical Sciences Branch (Mr. Nathan Lamie, Chief) of the of the Research and Engineering Division (Dr. George Calfas, Chief), U.S. Army Engineer Research and Development Center, Cold Regions Research Engineering Laboratory (ERDC-CRREL); the USACE New England District; and the U.S. Army Environmental Command. At the time of publication, the deputy director for ERDC-CRREL was Mr. Bryan E. Baker and the director was Dr. Joseph Corriveau.

This material was originally presented on 21 October 2021 at the Association for Environmental Health and Sciences Foundation (AEHS) virtual 37th Annual International Conference on Soils, Sediments, Water, and Energy.

COL Teresa A. Schlosser was the commander of ERDC and the director was Dr. David W. Pittman.

VI PREFERENTIAL PATHWAYS OF A LARGE GOVERNMENT BUILDING

Prepared by Jay Clausen, ERDC-CRREL
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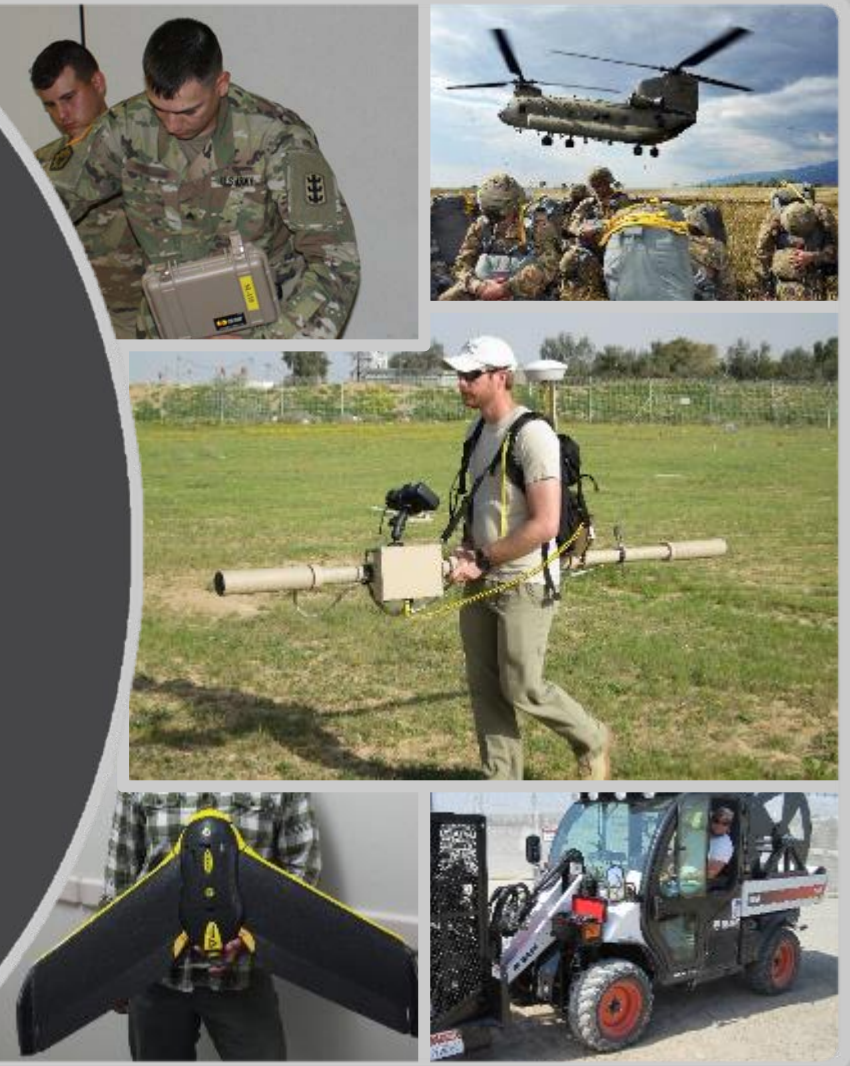
D. Moore, K. Miller, USACE NAE

L. Haines-Ecklund (USAEC)

21 October 2021



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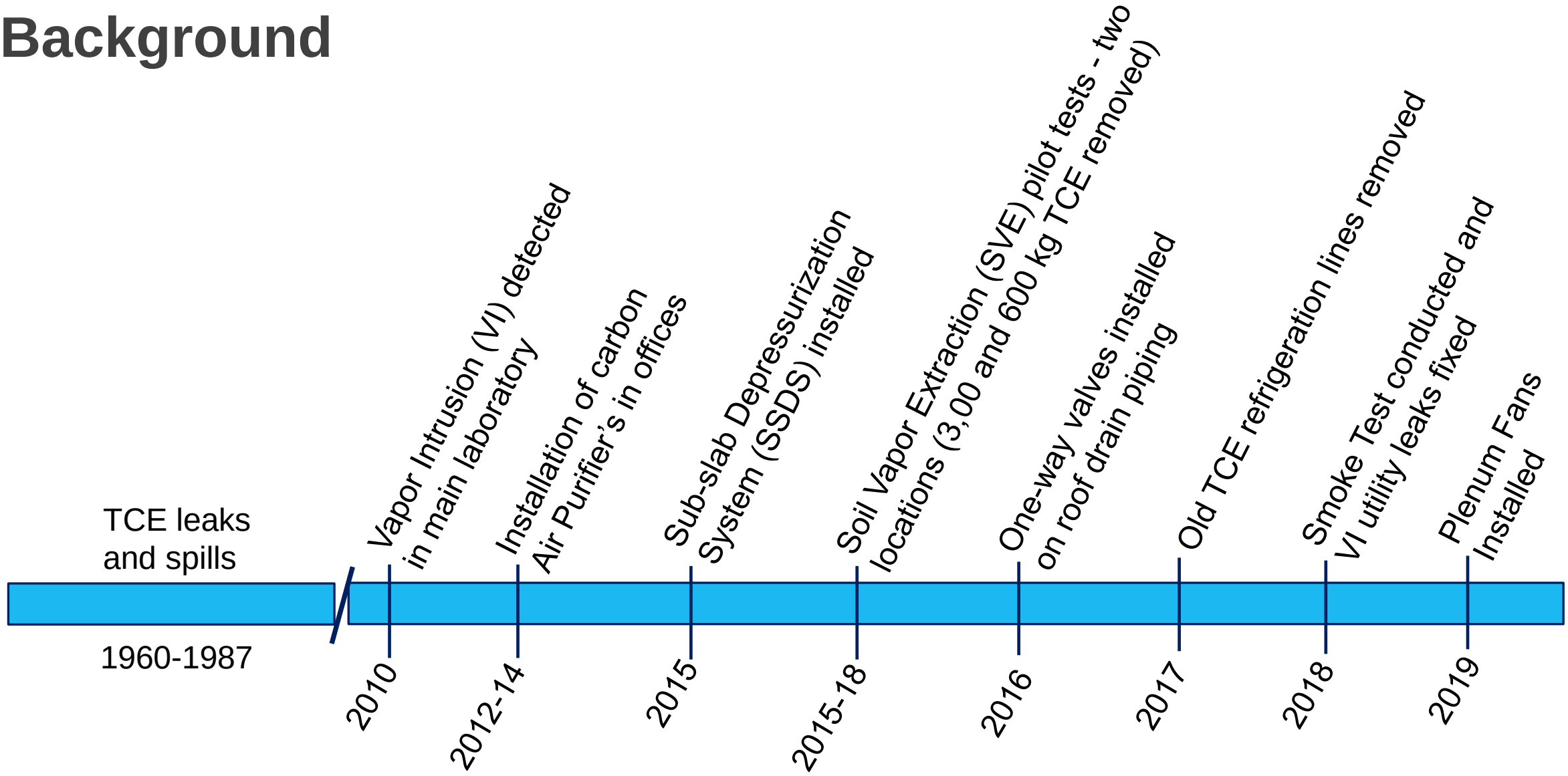
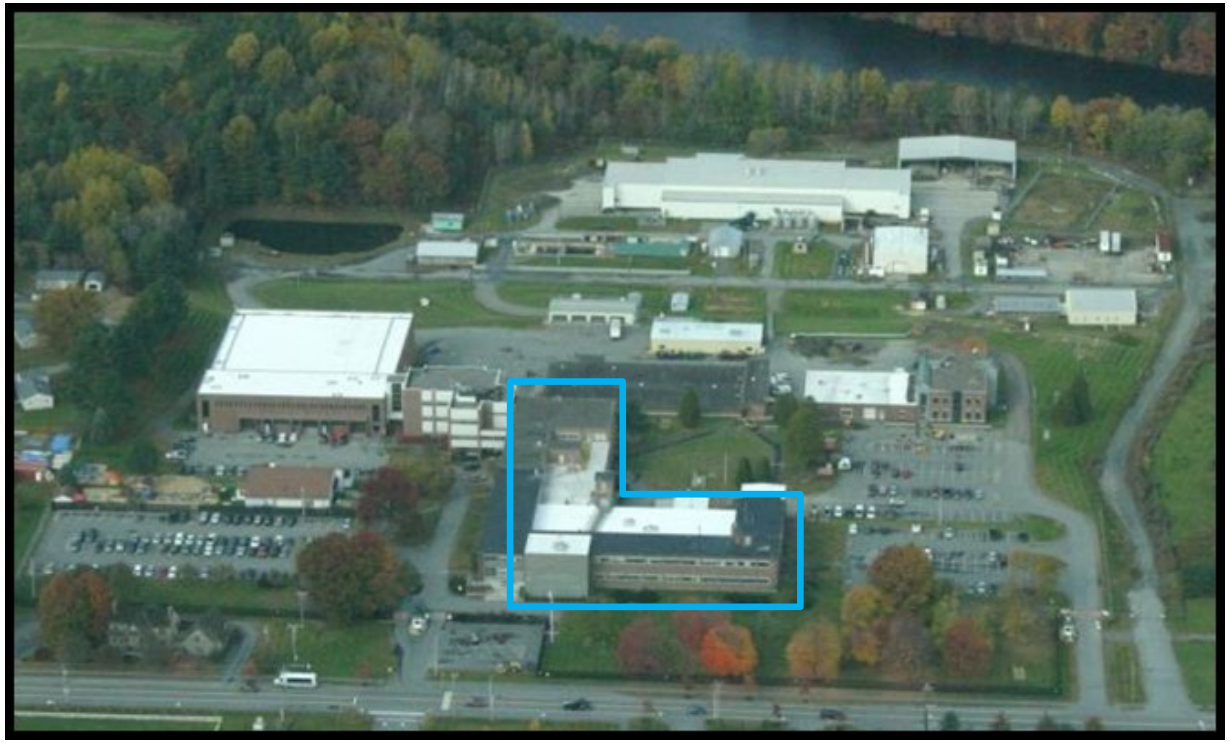
Background


TCE leaks and spills
1960-1987
2010
Vapor Intrusion (VI) detected in main laboratory
2012-14
Installation of carbon Air Purifier's in offices
2015
Sub-slab Depressurization System (SSDS) installed
2015-18
Soil Vapor Extraction (SVE) pilot tests - two locations (3,00 and 600 kg TCE removed)
2016
One-way valves installed on roof drain piping
2017
Old TCE refrigeration lines removed
2018
Smoke Test conducted and VI utility leaks fixed
2019
Plenum Fans Installed

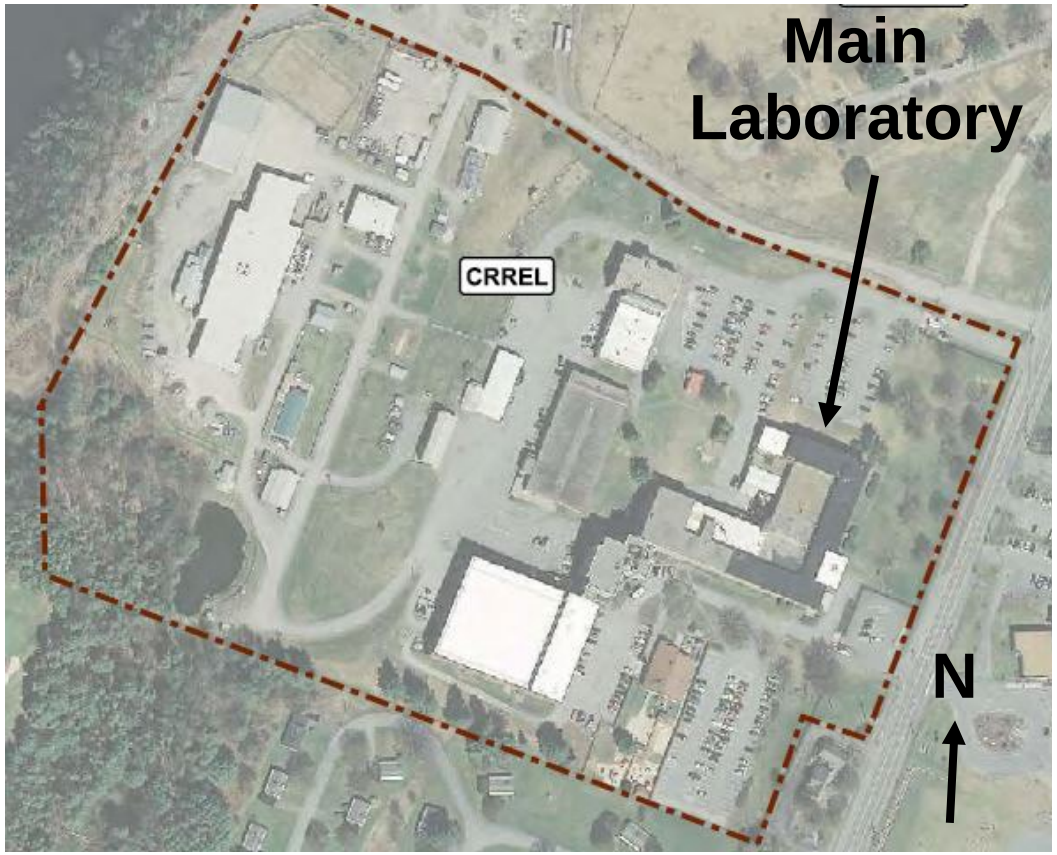
Pre-Remedial Contaminant Distribution

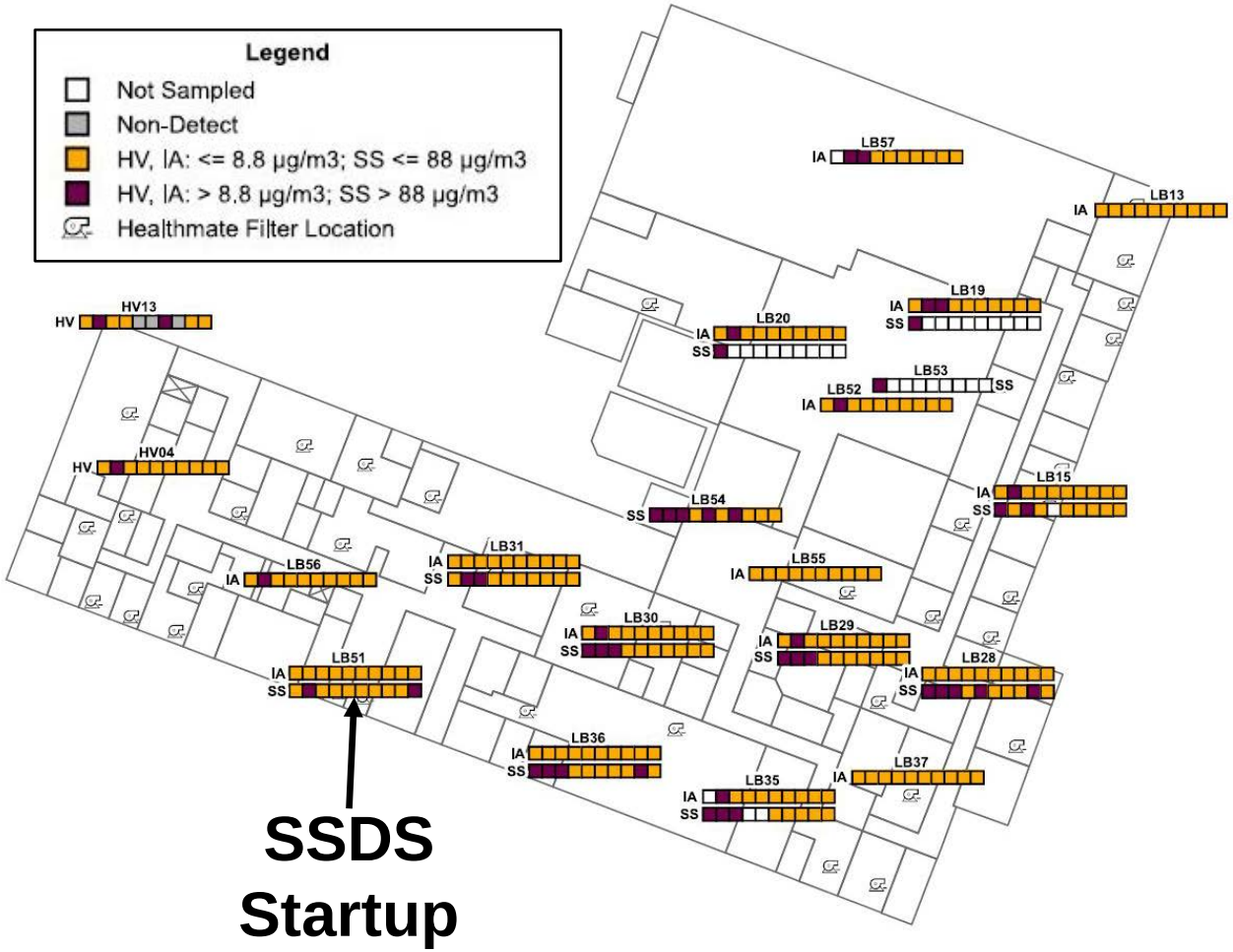
In and Around Main Laboratory

- **Subsurface soil gas TCE concentrations in excess of 10,000,000 ug/m^3**
- **Sub-slab TCE concentrations up to 5,900,000 µg/m^3**
- **Indoor air sub-basement TCE concentrations, 25 to 91 µg/m^3**
- **Indoor air basement TCE concentrations, 15 to 241 µg/m^3**
- **Indoor air 1st floor TCE concentrations, 0.86 to 4.7 µg/m^3**
- **Indoor air 2nd floor TCE concentrations, 2.5 to 48 µg/m^3**

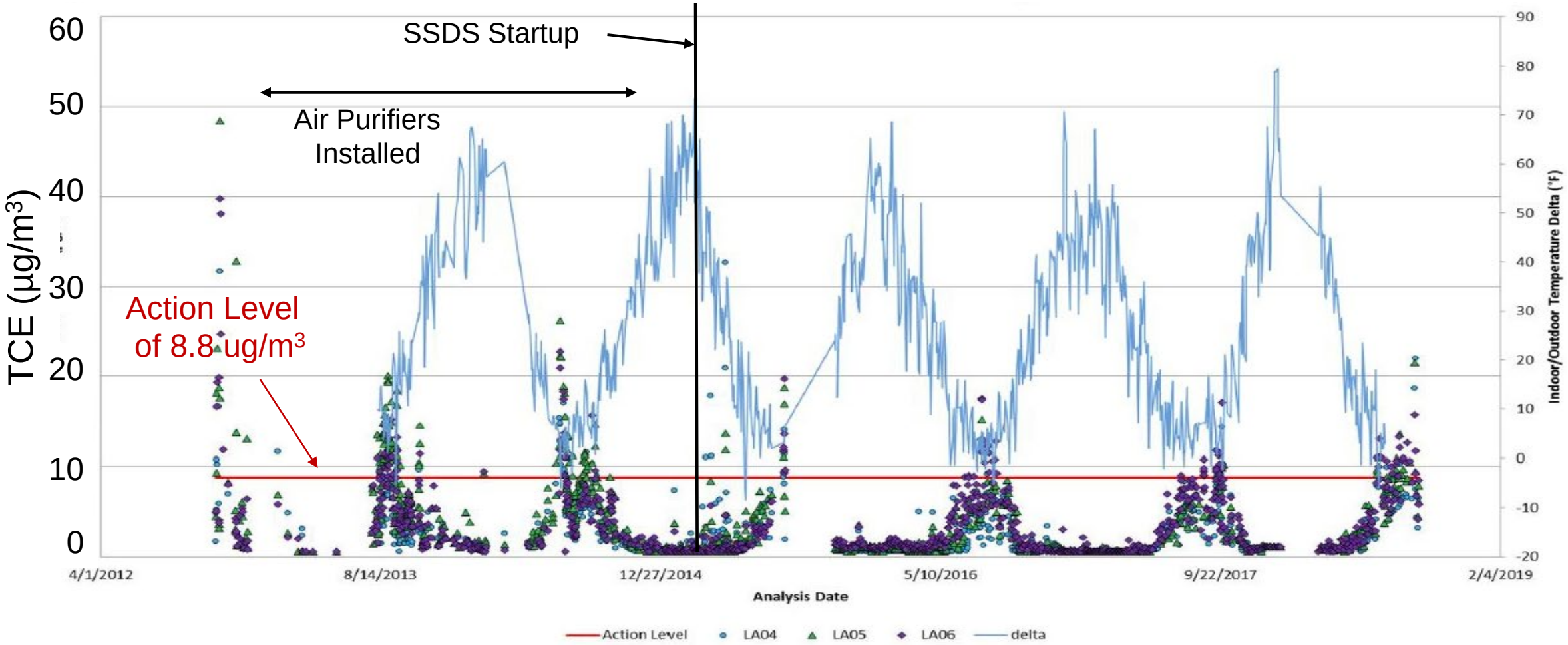


Sub Slab Depressurization (SSDS)

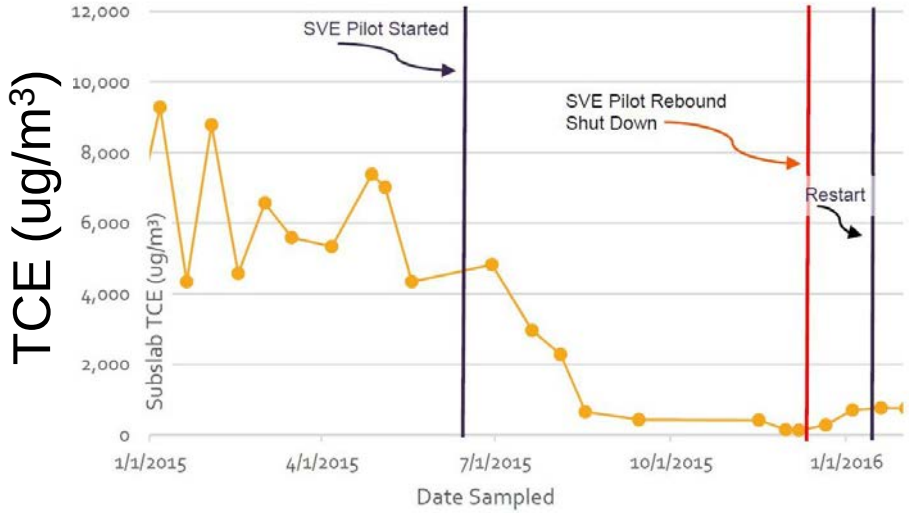




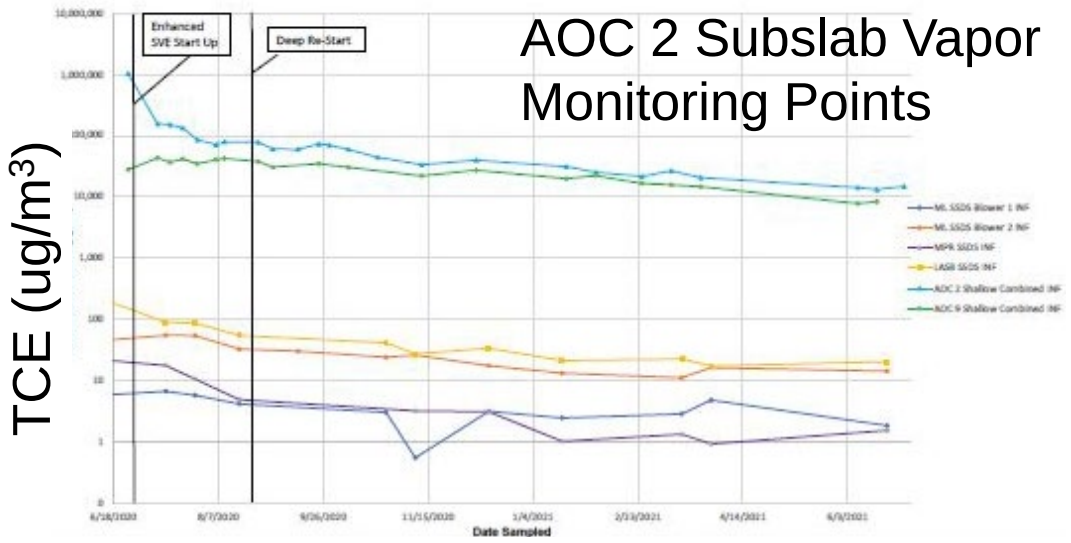
TCE Levels Second Floor



Soil Vapor Extraction Impacts on Subslab Vapor

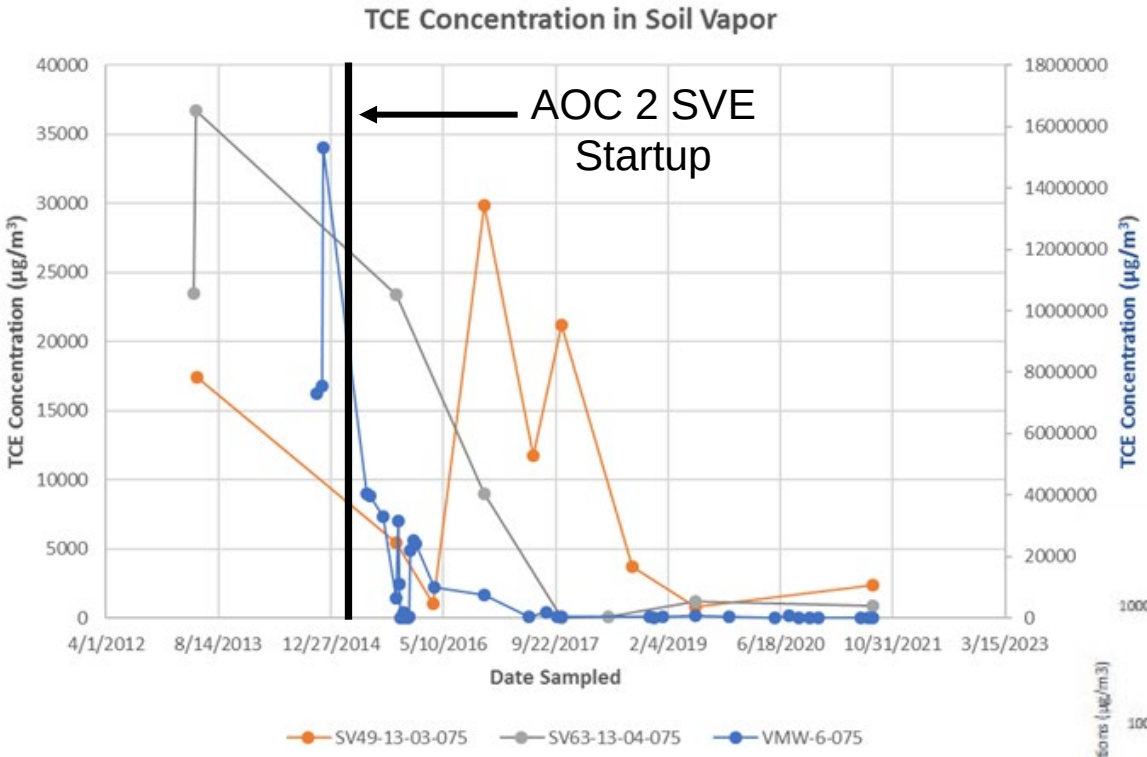


AOC 2 SSDS Influent

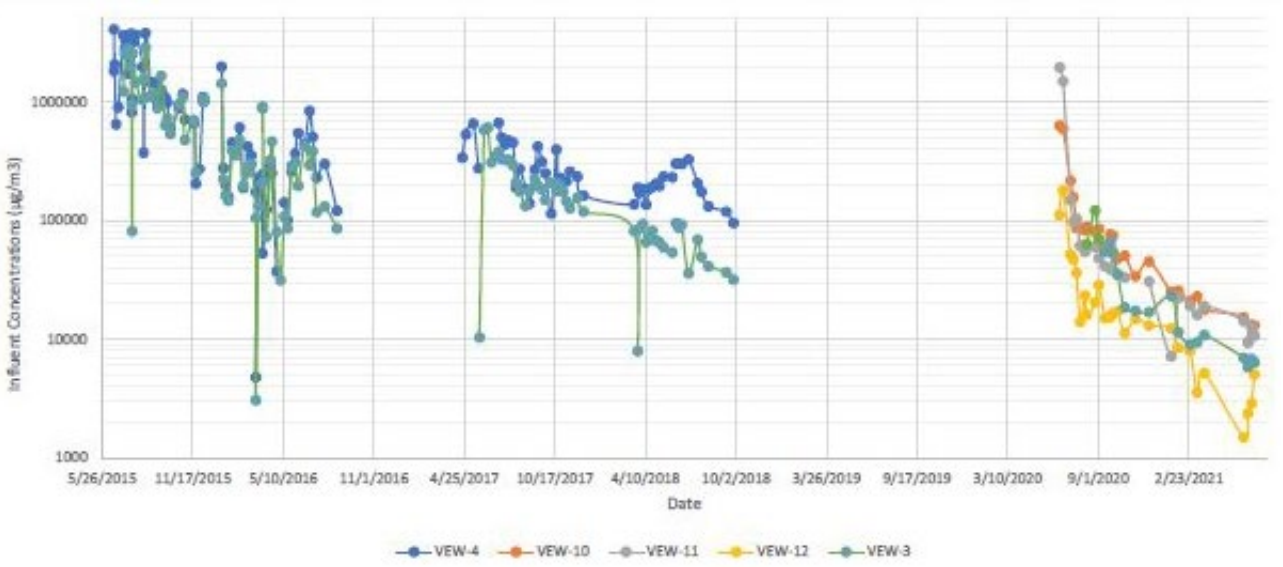


AOC 2 Subslab Vapor Monitoring Points

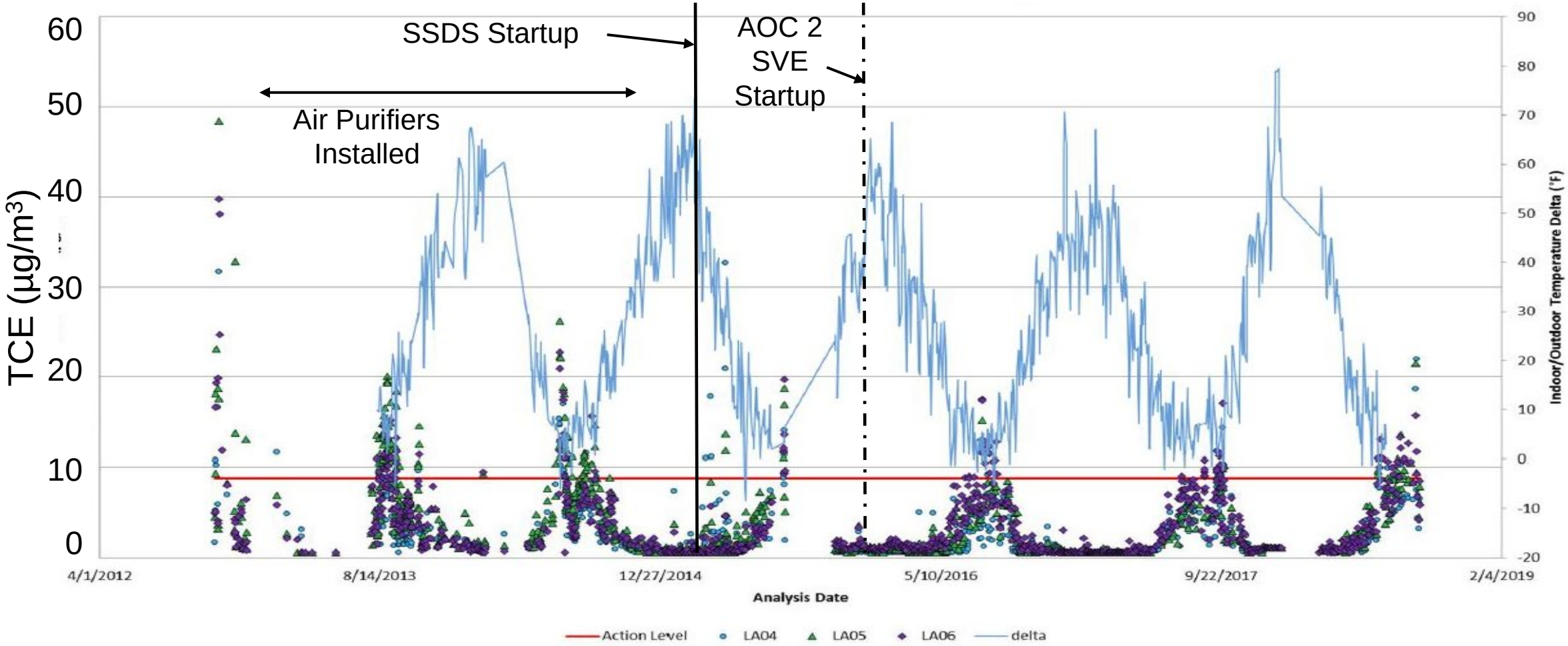
Soil Gas Levels



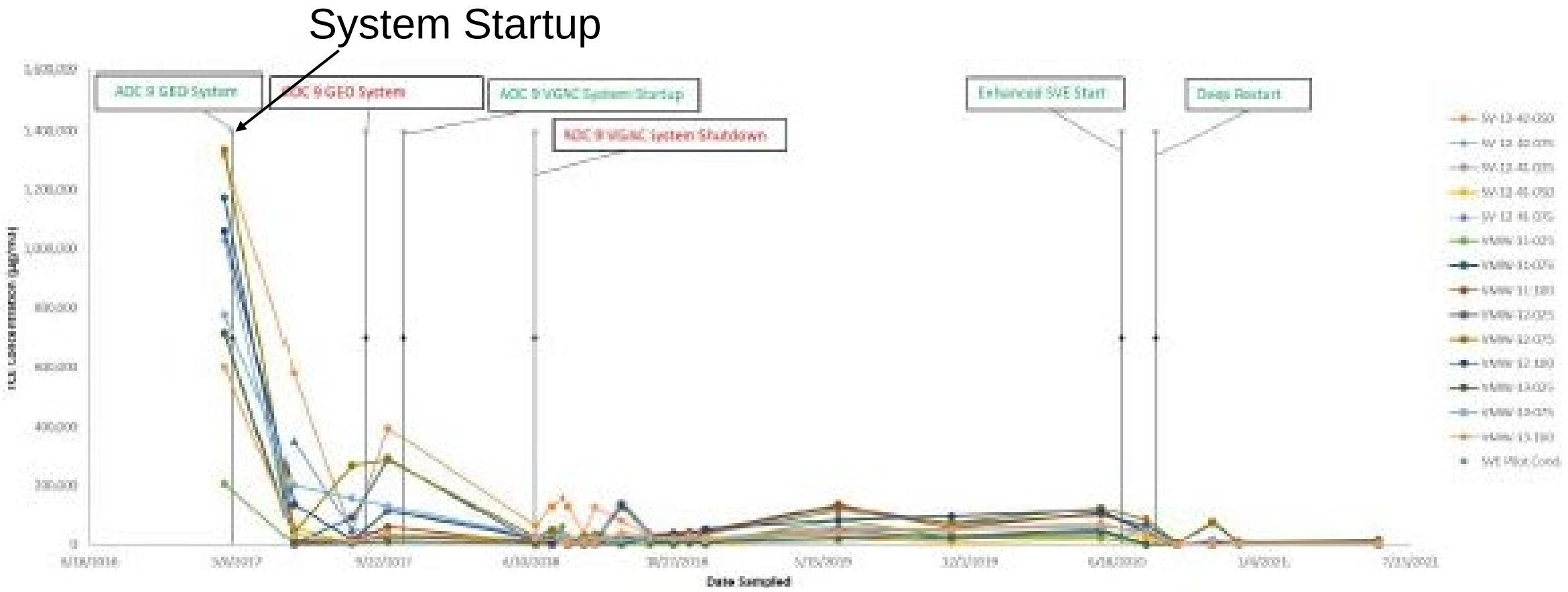
AOC 2 SVE Influent



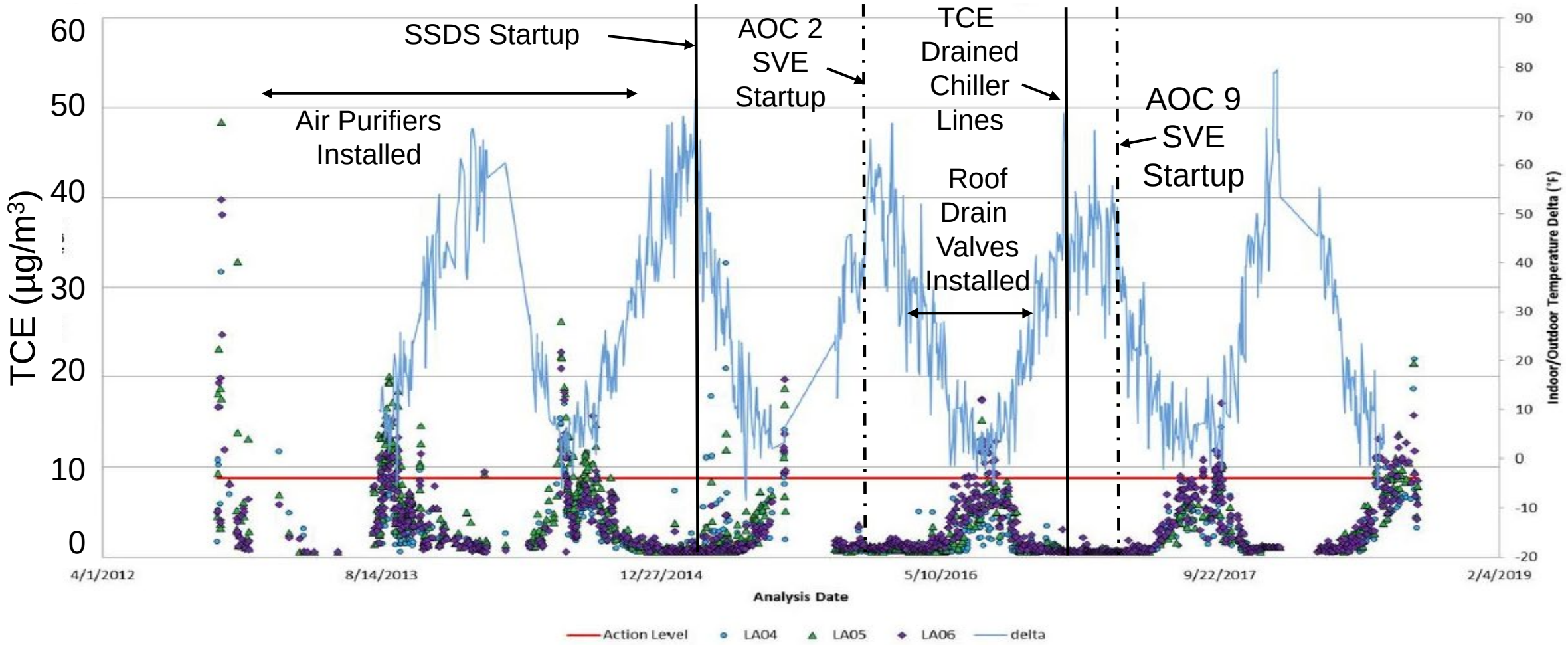
TCE Levels Second Floor



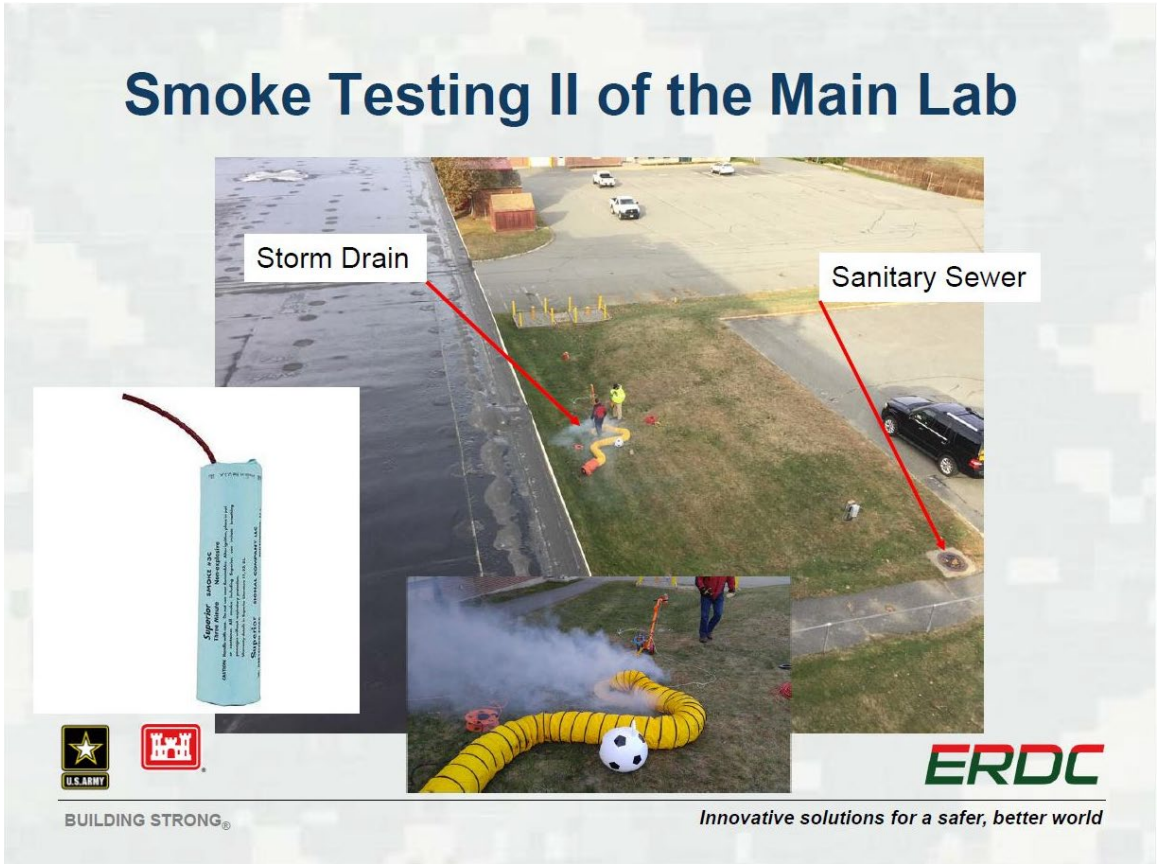
AOC 9 SVE Soil Monitoring



TCE Levels Second Floor



Smoke Testing



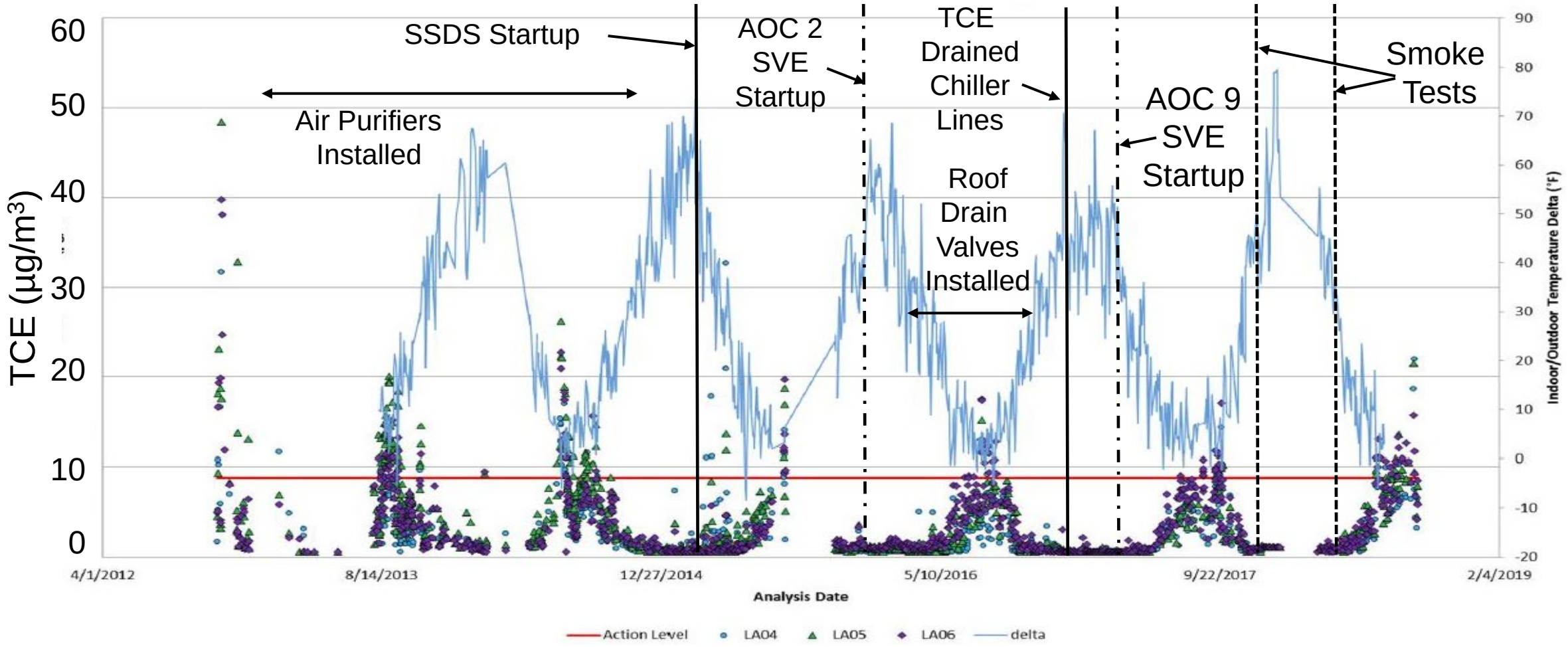
Smoke Testing

Toilet Seal

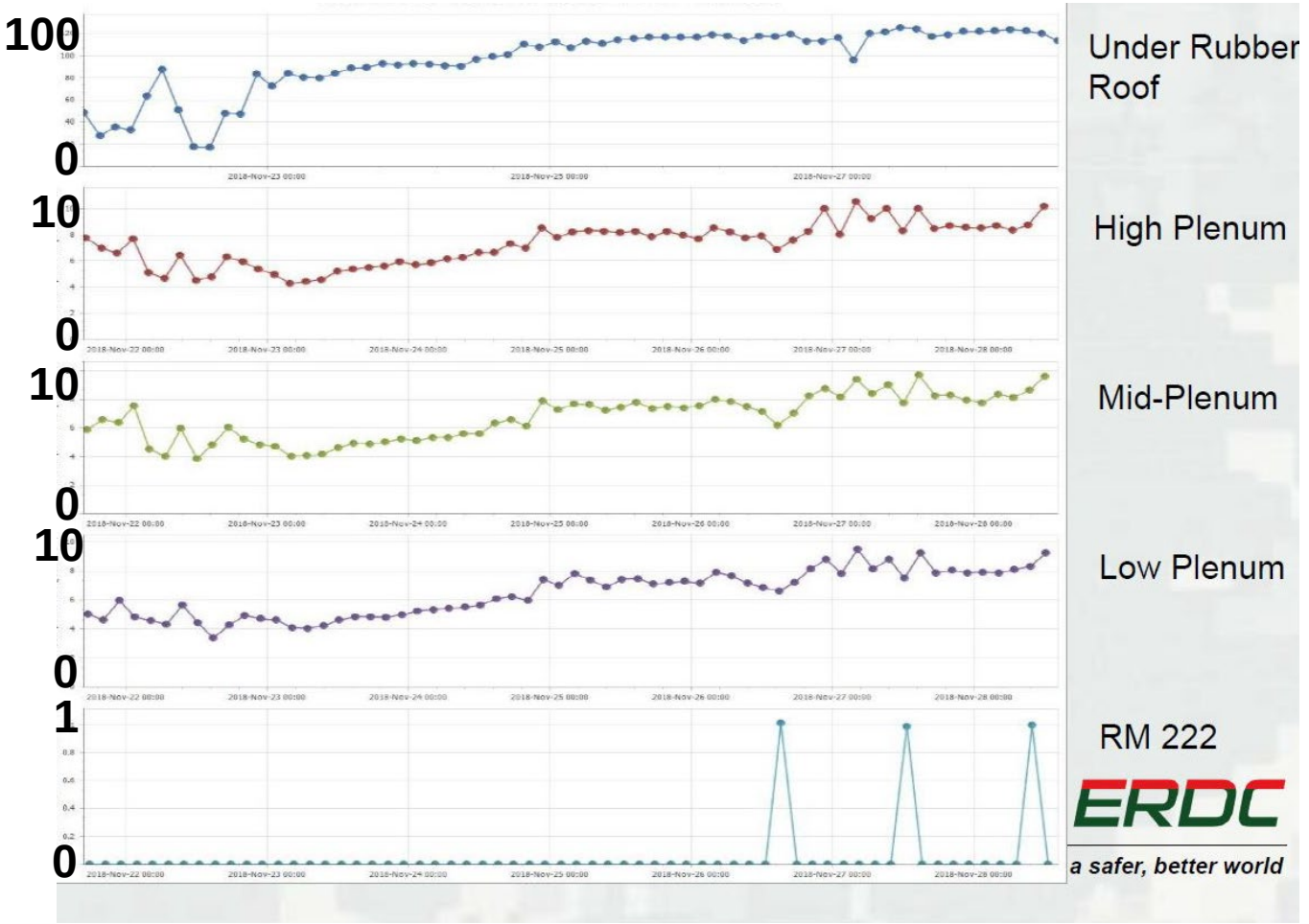
Sanitary Sewer Line
Above Suspended Ceiling

Open Pipe Beneath
Raised Floor

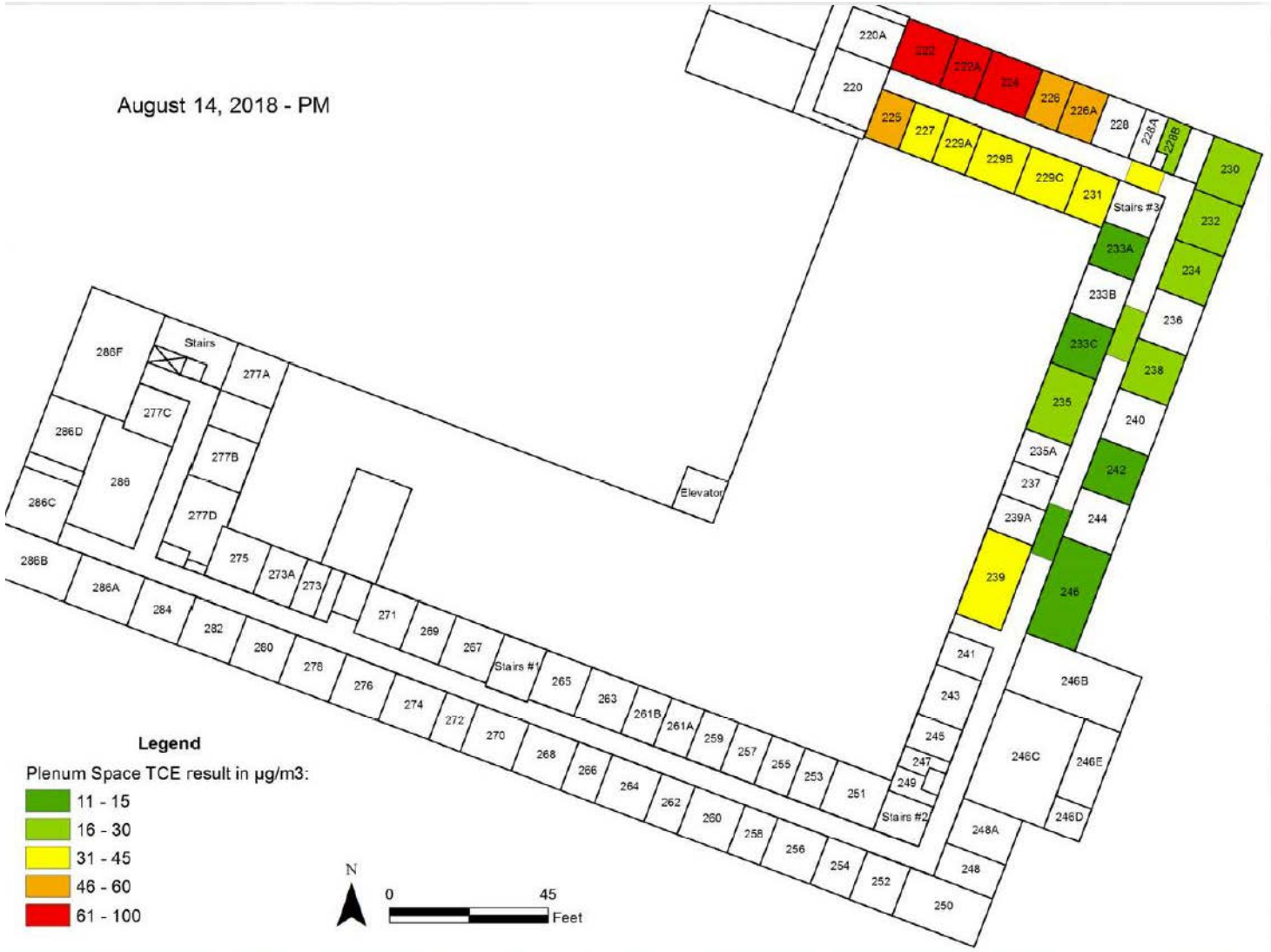
TCE Levels Second Floor



Plenum TCE Levels



TCE Distribution in Plenum



TCE Distribution in Plenum

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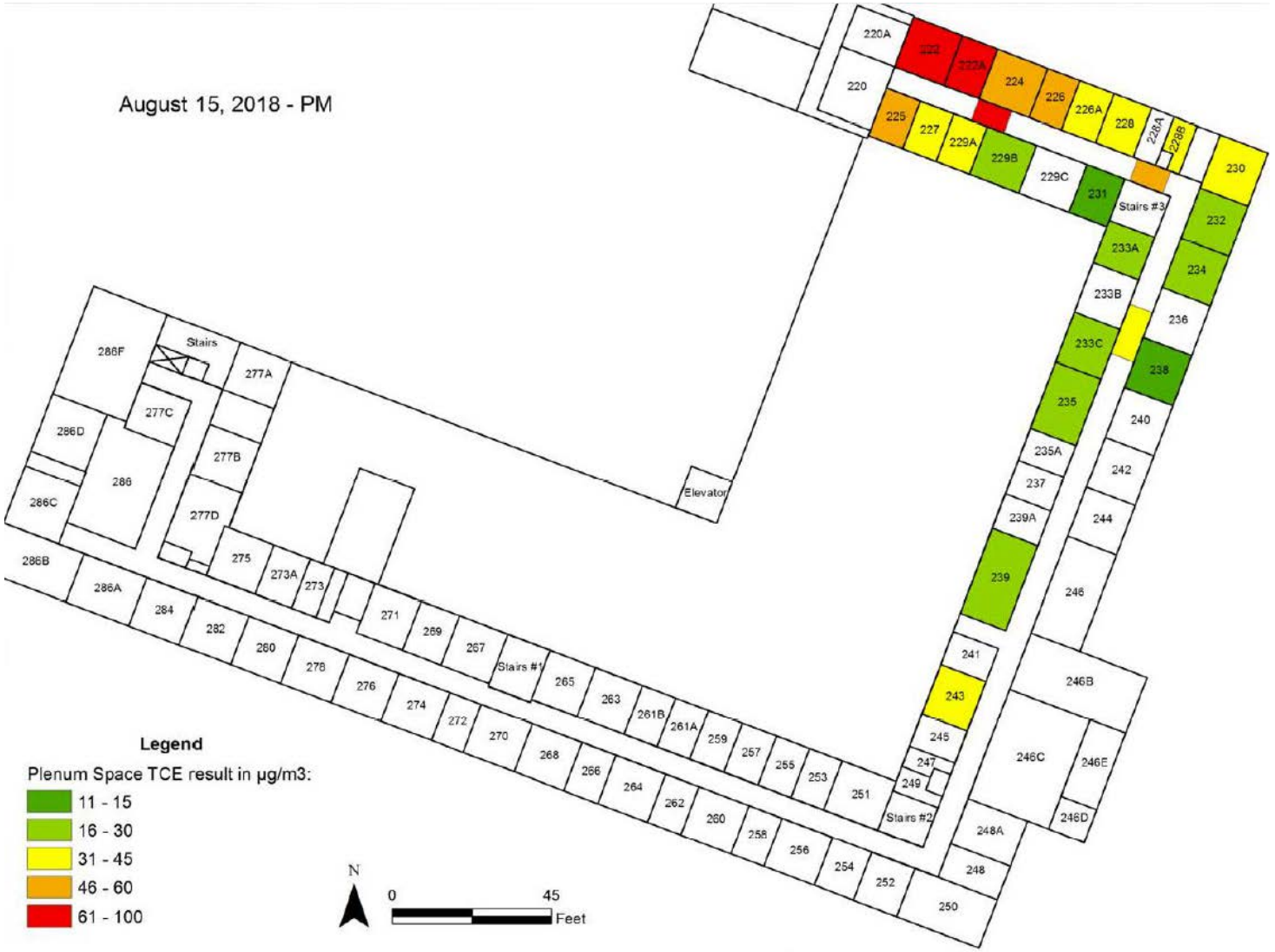
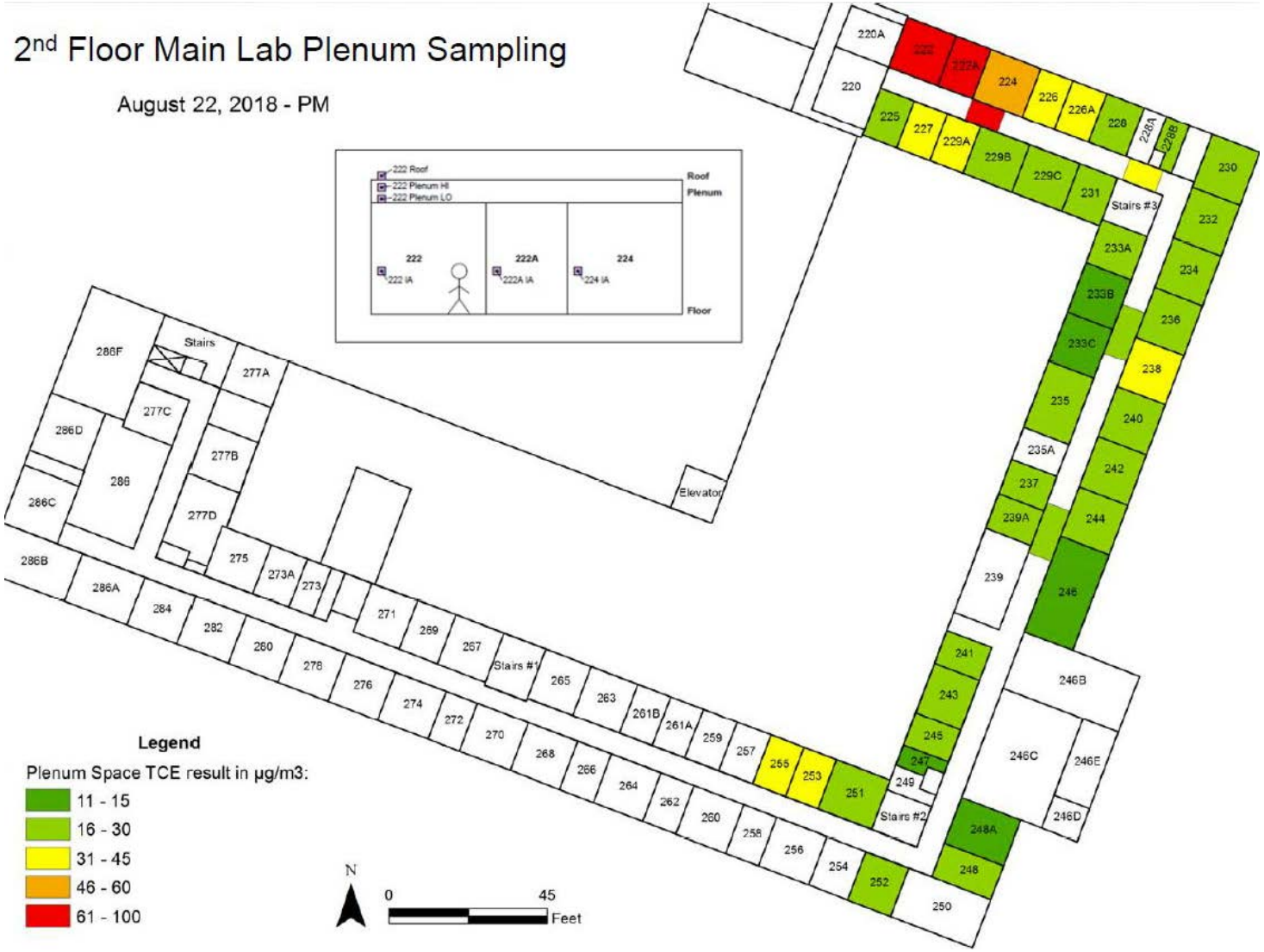
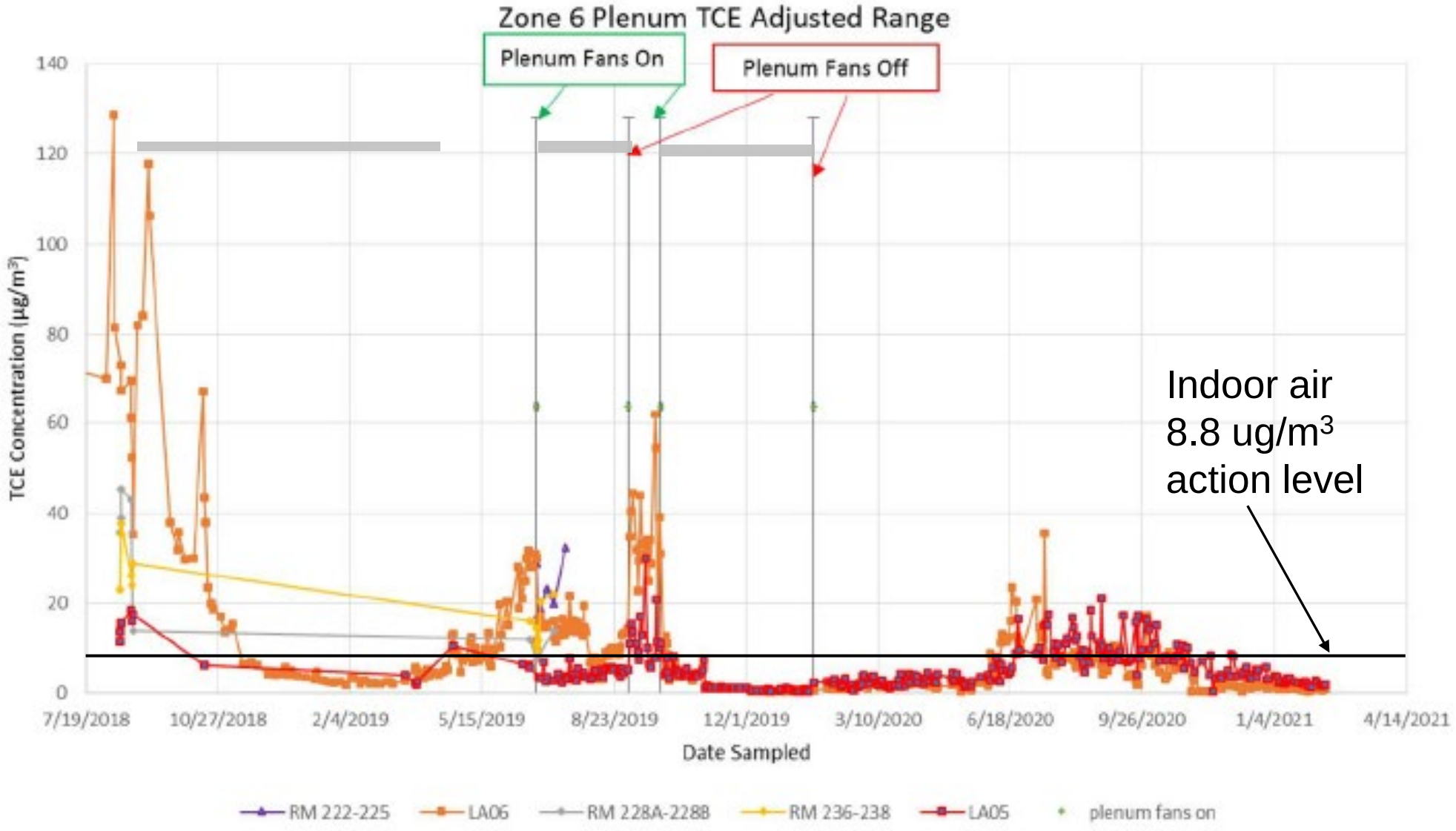


TCE Distribution in Plenum



Indoor Air Second Floor TCE Trends since Remediation



Current Status

- SSDS influent TCE levels below 880 ug/m^3 regulatory guideline
- Subslab TCE vapor concentrations generally below 100,000 ug/m^3
- No rebound of TCE observed at SVE pilot-test locations
- AOC 2 SVE – ~ 3,000 kg TCE removed
- AOC 9 SVE – ~ 600 kg TCE removed
- Periodic TCE fluctuations above action levels in second floor north wing offices in late Summer prior to 2019
- Sampling of roof materials in Spring 2019
- Installed carbon air purifiers in the plenum space early Summer 2019
- TCE concentrations in plenum space reduced and second floor offices (below action levels) since Fall 2020

Conclusions

- **Vapor emanations along utility lines (roof drains, sewer lines, refrigeration lines), elevator shaft, volatile back diffusion from building materials (concrete, insulation, roofing) and other sources are underestimated and being missed**
- **Periodic SUMA canister sampling is insufficient for assessing VI variability, determining exposure pathways, and quantifying exposure**
- **Extrapolation of VI pathways from residential studies to industrial sites is inappropriate and misleading**
- **Term VI should be all encompassing not only emanations through sub-slab but emanations from volatile back diffusion of building materials and subsurface preferential pathways (utility lines)**

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This information was originally presented at the *Association for Environmental Health and Sciences Foundation (AEHS) virtual 37th Annual International Conference on Soils, Sediments, Water, and Energy* on 21 October 2021.
Funding was under MIPR Customer Order 11415853.

14. ABSTRACT

Trichloroethylene (TCE) releases from leaks and spills next to a large government building occurred over several decades with the most recent event occurring 20 years ago. In response to a perceived conventional vapor intrusion (VI) issue a sub-slab depressurization system (SSDS) was installed 6 years ago. The SSDS is operating within design limits and has achieved building TCE vapor concentration reductions. However, subsequent periodic TCE vapor spikes based on daily HAPSITE™ measurements indicate additional source(s).

Two rounds of smoke tests conducted in 2017 and 2018 involved introduction of smoke into a sanitary sewer and storm drain manholes located on effluent lines coming from the building until smoke was observed exiting system vents on the roof. Smoke testing revealed many leaks in both the storm sewer and sanitary sewer systems within the building. Sleuthing of the VI source term using a portable HAPSITE™ indicate elevated vapor TCE levels correspond with observed smoke emanation from utility lines.

Sleuthing activities also found building roof materials explain some of the elevated TCE levels on the 2nd floor. Installation of an external blower in the roof truss space has greatly reduced TCE levels. Preferential VI pathways and unexpected source terms may be overlooked mechanisms as compared to conventional VI.

15. SUBJECT TERMS

Trichloroethylene, Indoor air pollution, Air quality management

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