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Using Active Subslab Depressurization to Mitigate Diffusion-Based Vapor Intrusion

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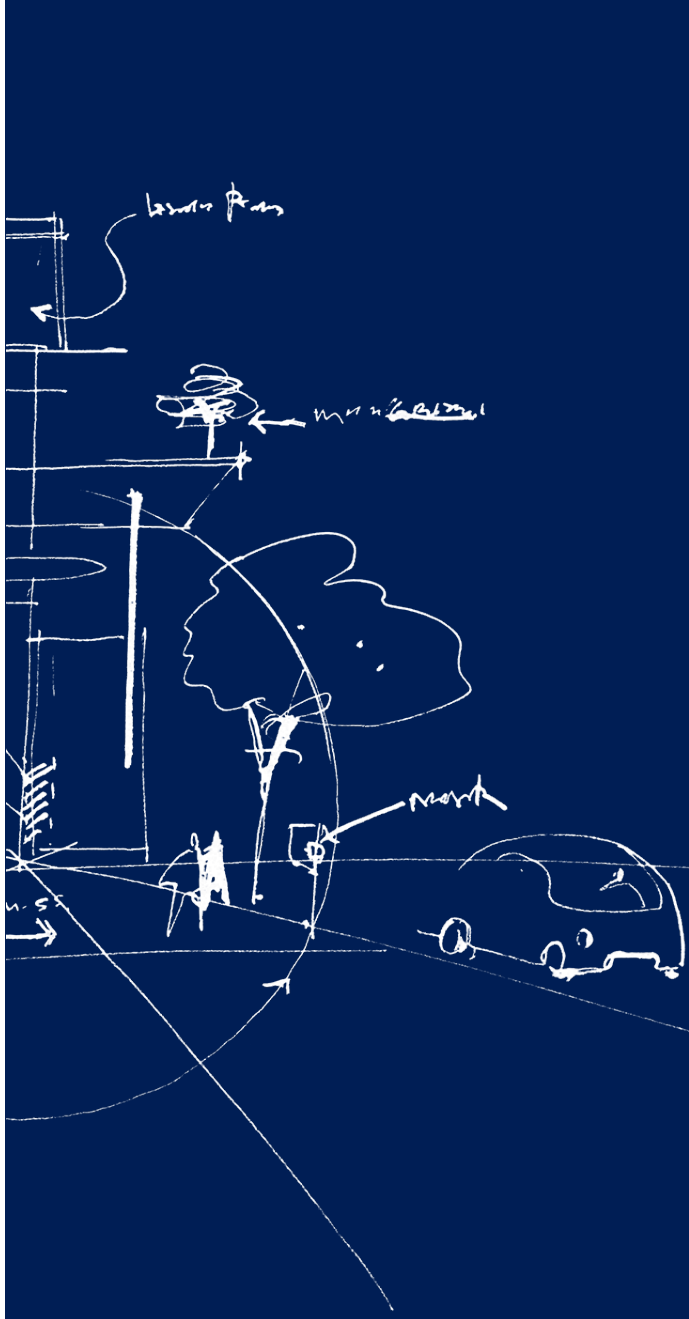
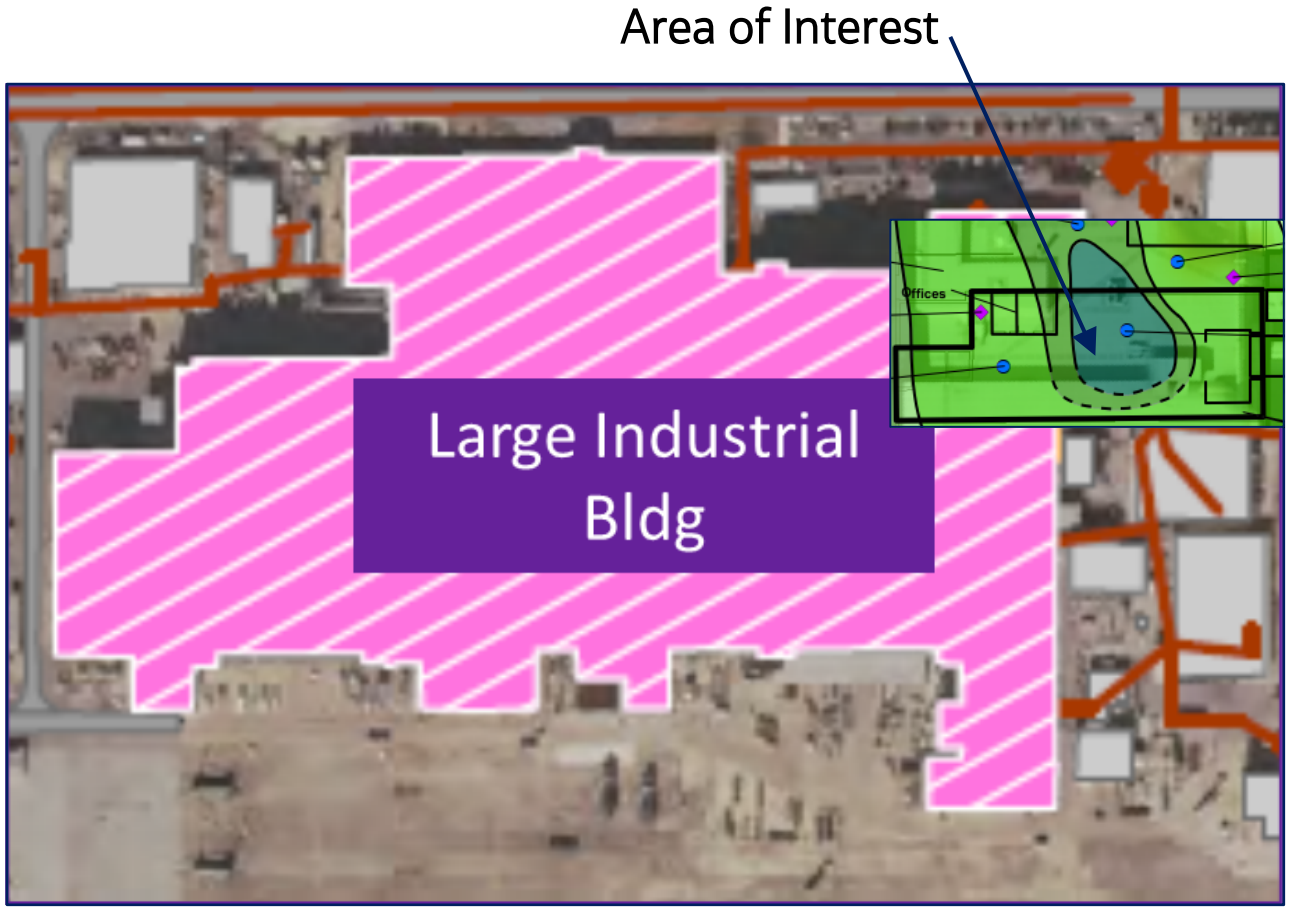
Agenda

- Introduction
- Site Background
- Alternatives Analysis
- Vapor Intrusion Mitigation System Installation
- Post-Startup Monitoring
- Conclusions



Site Background

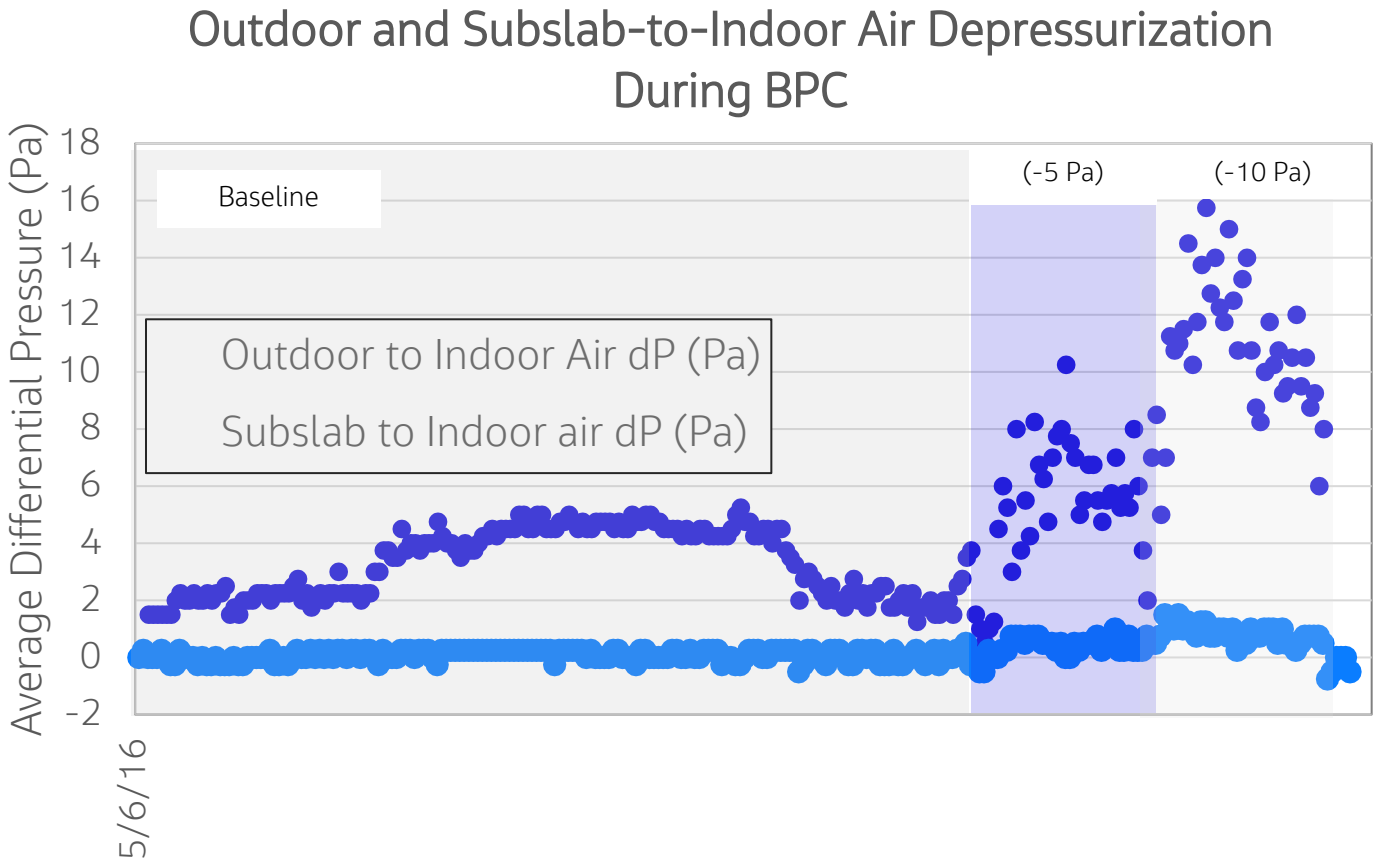
- Approximately 620,000 ft^2 single story building, used as a maintenance shop
- Indoor sampling conducted as part of long-term monitoring suggested VI in a subarea of the building
  - Indoor air TCE concentration ~10 $\mu g/m^3$
  - Max subslab TCE 140,000 $\mu g/m^3$
  - Significant settling and multiple cracks observed in the slab
- HAPSITE Survey, BPC, and flux chamber were used to evaluate vapor entry mechanisms in 4,840 ft^2 compartment

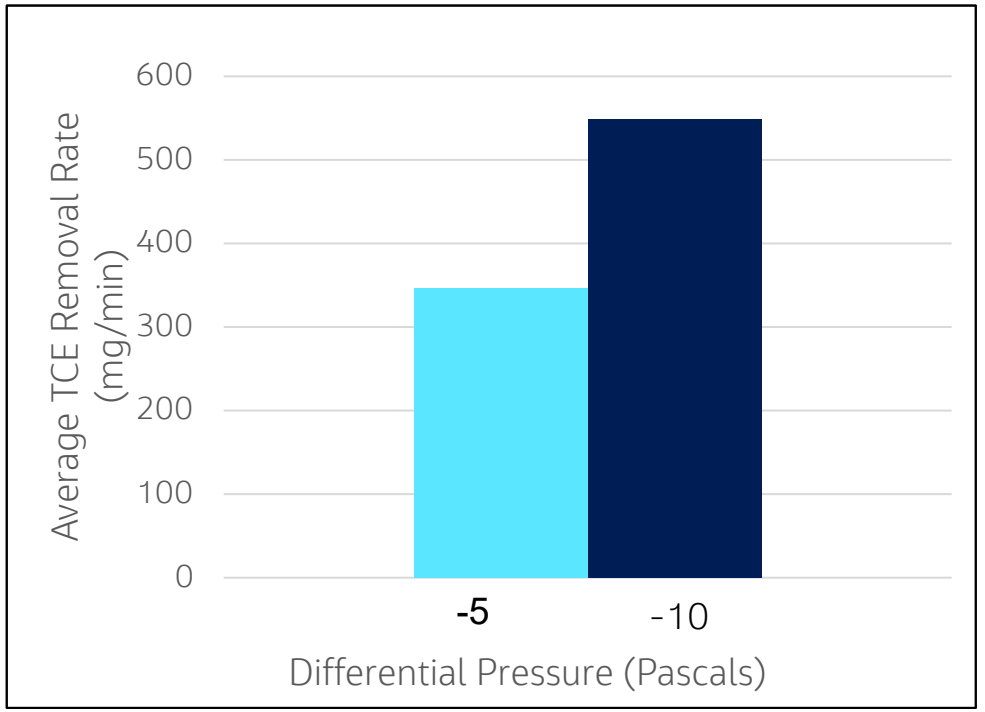


(CH2M 2017)

ft^2: square feet
$\mu g/m^3$: micrograms per cubic meter
BPC: Building Pressure Cycling

BPC Results





(CH2M 2017)

µg/min: micrograms per minute
BPC: Building Pressure Cycling
dP: differential pressure
IA: indoor air
Pa: Pascal
TCE: trichloroethene

BPC confirmed detected IA concentrations were due to VI

Flux Chamber Results

- ~25 ft^2 chamber constructed in area with no visible cracks
- Over 2-hour period, steady increase in concentration within the chamber
  - 282 $\mu g/m^3$ to 655 $\mu g/m^3$
- TCE migration occurring across slab
- Predicted indoor air concentration based on flux - 10 $\mu g/m^3$
  - Consistent with measured indoor air concentration (Summa)

(Jacobs 2022)

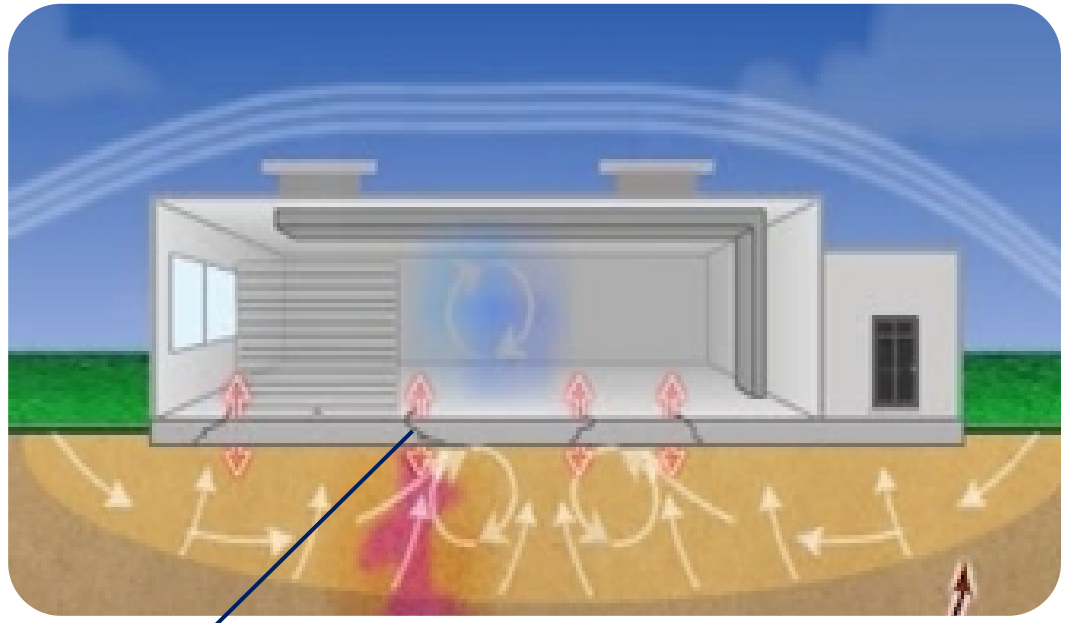
Flux chamber testing indicated the primary mechanism for VI was **diffusion** across the slab

ft^2: square feet
$\mu g/m^3$: micrograms per cubic meter
TCE: trichloroethene

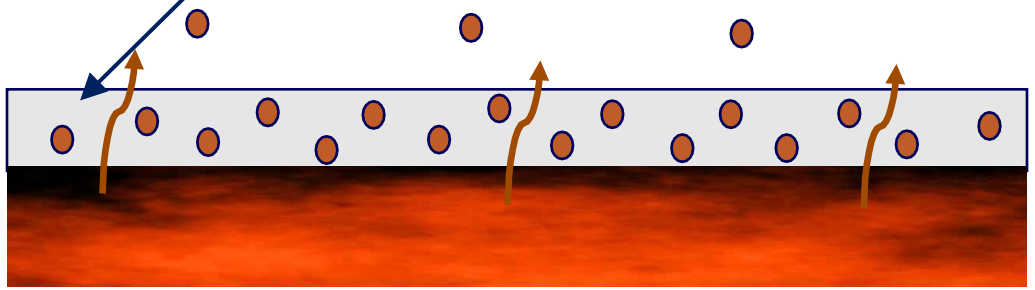
Diffusion Mechanics

- Movement of molecules from high concentration to low concentration
- Depends on random movement of molecules
- Not dependent on pressure gradients

Mitigation measures needed to both reduce mass accumulation below the slab and to create negative pressure for advective flow



(CH2M 2016)



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Alternatives Analysis

- Performed initial screening of VI mitigation alternatives. The most viable alternatives were carried forward for a detailed evaluation:
  - Alternative 1—Horizontal Soil Vapor Extraction (SVE)
  - Alternative 2—Heating, Ventilation, and Air Conditioning (HVAC) System Replacement
  - Alternative 3—Active Subslab Depressurization (SSD)
- Preferred Option: Subslab Depressurization (Alternative 3)
  - Provides subsurface contaminant mass removal
  - Disconnects the complete VI pathway by depressurizing the slab and venting the captured soil gas outside the building
  - Vertical SSD nodes minimize contact with potential subsurface utilities and risers would be placed along walls to minimize disruptions to facility operations

HVAC: heating, ventilation, and air conditioning
SSD: subslab depressurization
SVE: soil vapor extraction

VIMS Installation

- 8 SSD nodes installed based on results of pressure field extension testing
  - Installed with dP transmitters set with operator-adjustable high and low alarms
- Additional subslab probes installed to measure dP and to collect subslab soil vapor samples
  - 5 installed with dP transmitters that continuously collect readings
- Ground-mounted regenerative blower located outside the building and fitted with a variable-frequency drive

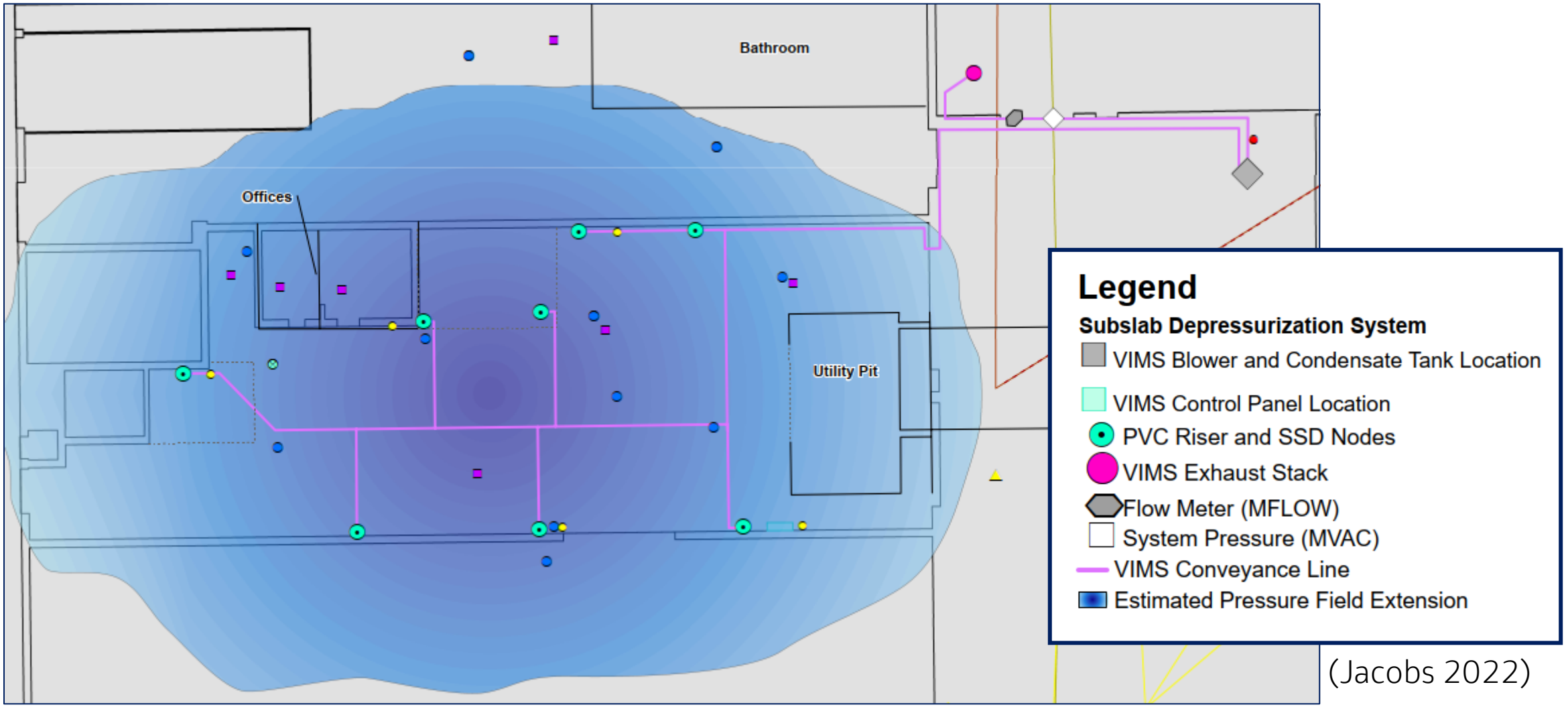




(Jacobs 2022)

dP: differential pressure
SSD: subslab depressurization

VIMS Layout



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VIMS Telemetry System

- VIMS Dashboard
  - Developed automated dashboard to track and update:
    - System operational parameters (e.g., flow, dPs, etc.)
    - Field-measured data (HAPSITE)
    - Analytical laboratory data (Summa)

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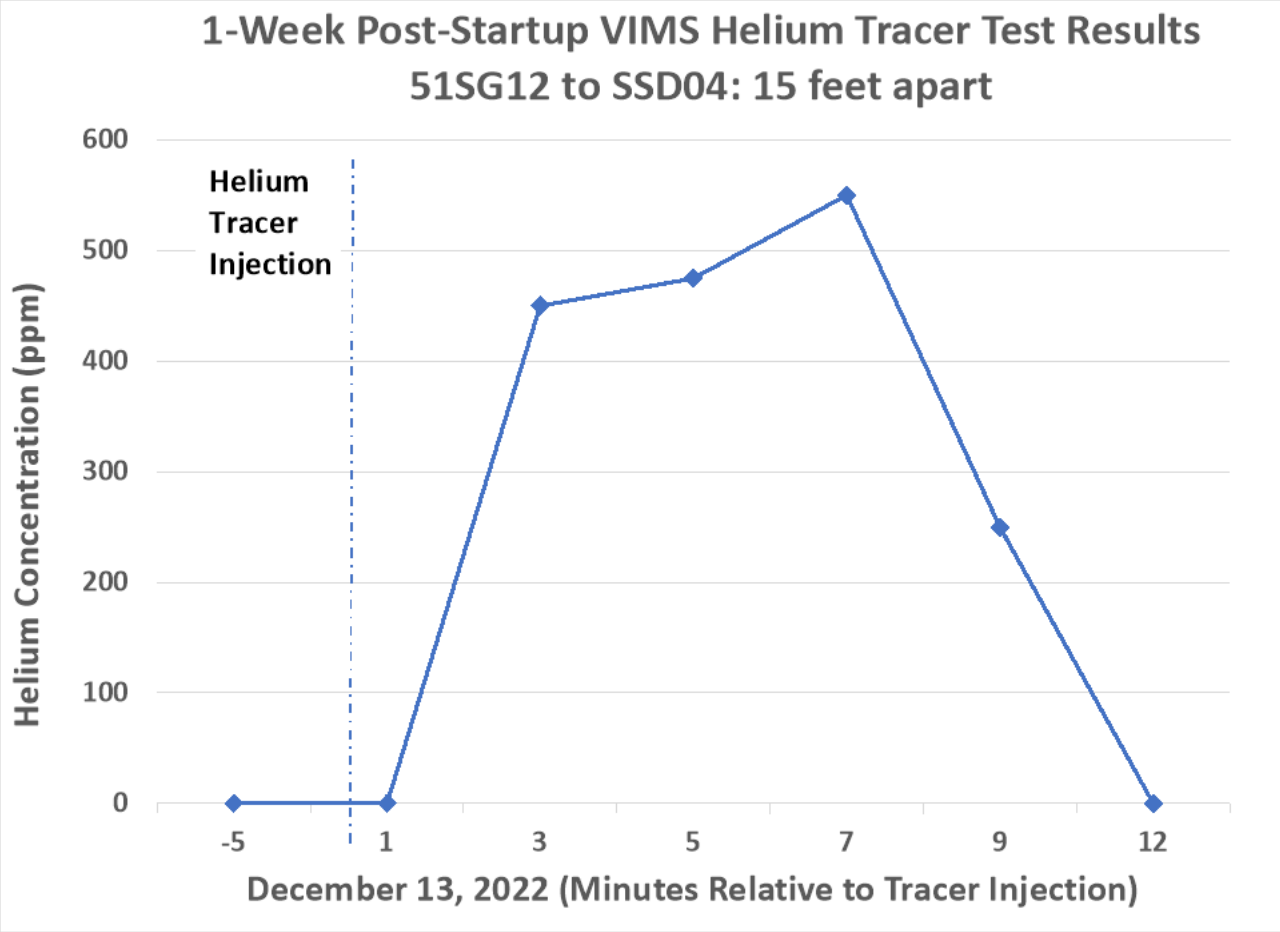
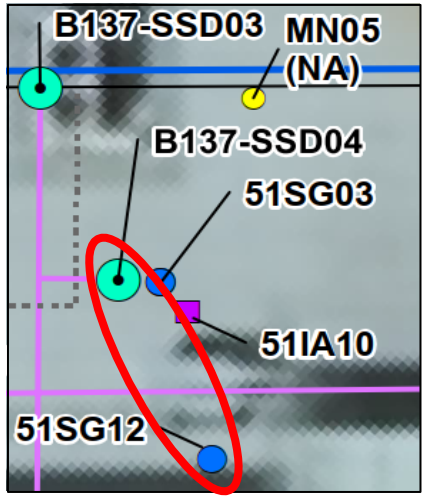
dP: differential pressure
VIMS: vapor intrusion mitigation system

Helium Tracer Testing



1-Week Post Startup:

- Injected helium at location 51SG12 and monitored for breakthrough 15 feet away at SSD04
- Data provided a line of evidence indicating direct connection to SSD risers from the most impacted locations in the middle of the maintenance shop



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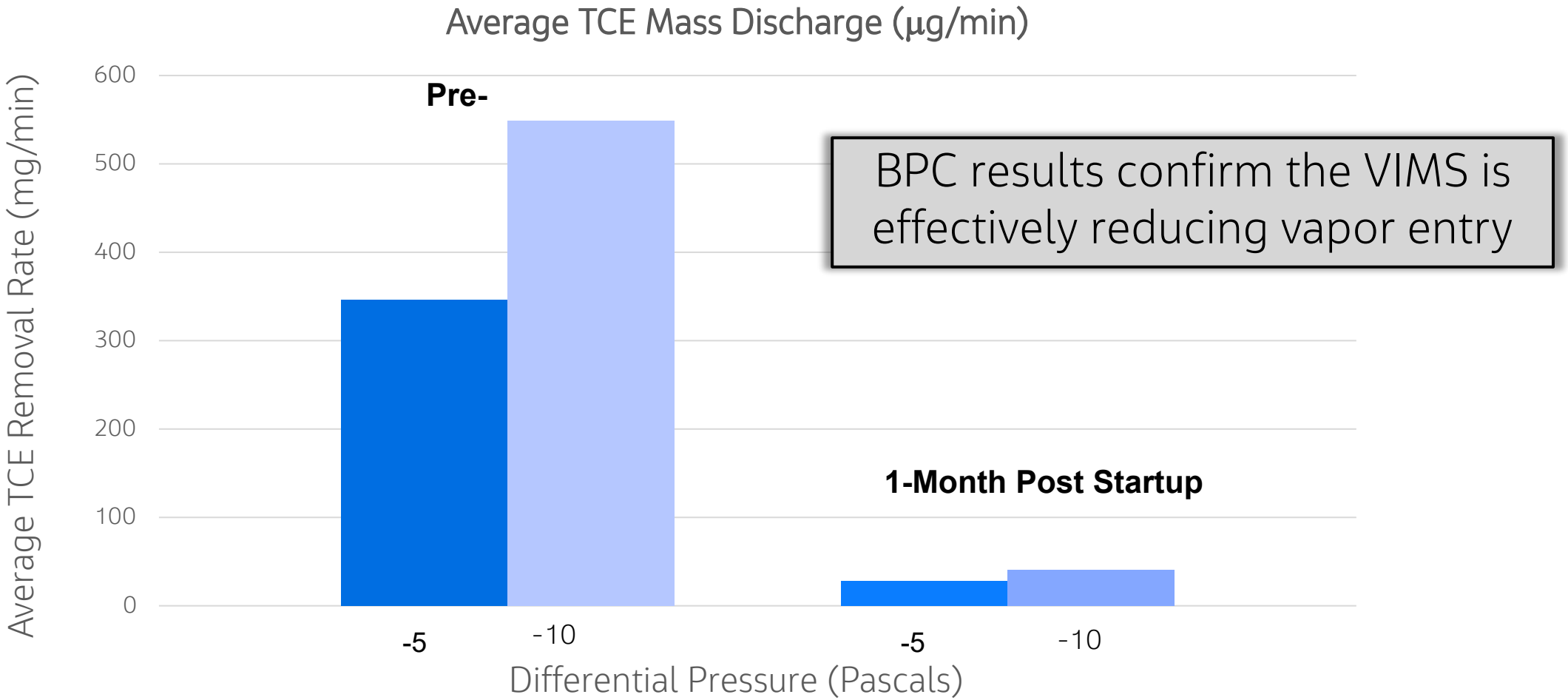
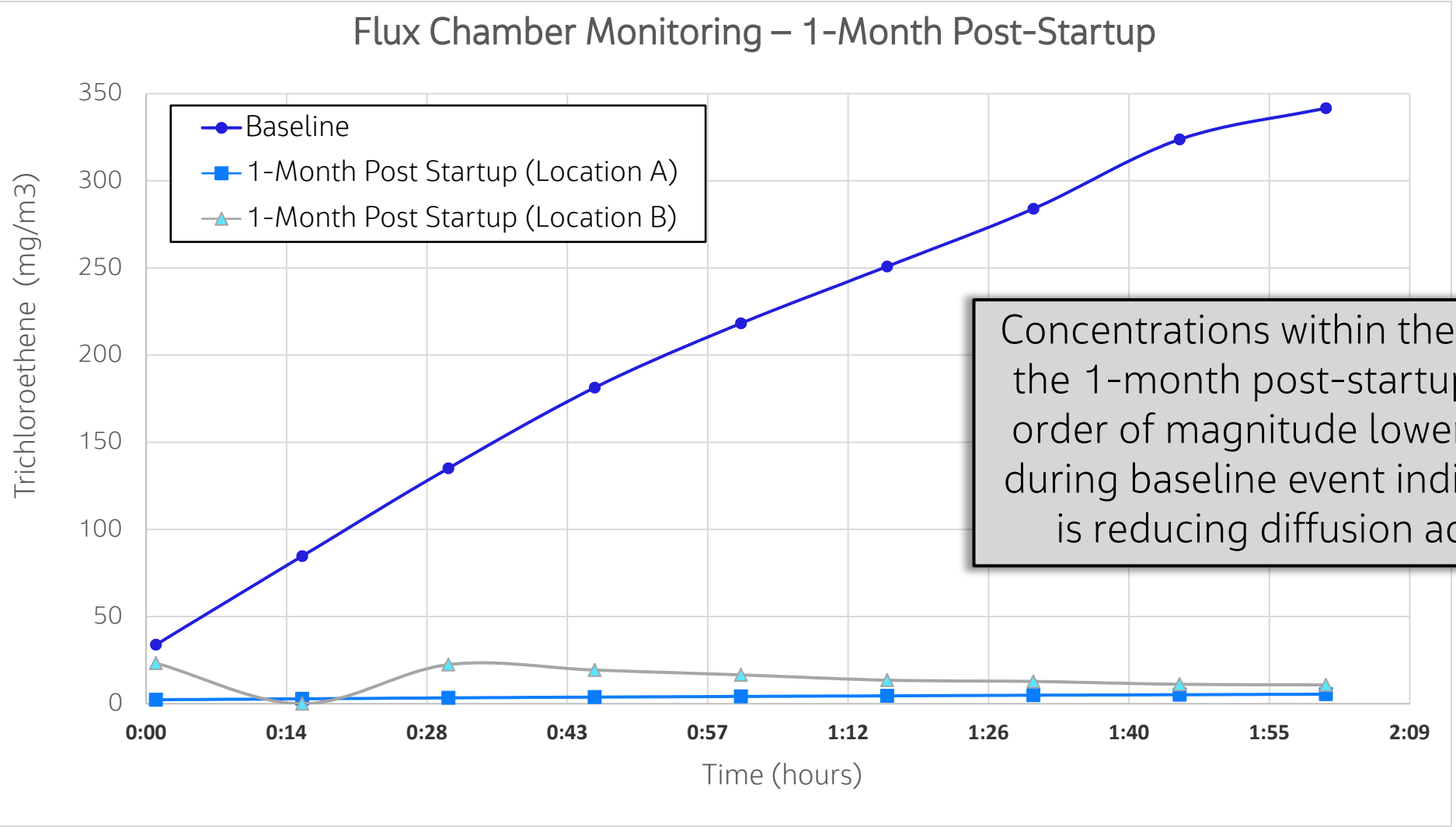
ppm: parts per million

Building Pressure Cycling



µg/min: micrograms per minute
BPC: Building Pressure Cycling
TCE: trichloroethene
VIMS: vapor intrusion mitigation system

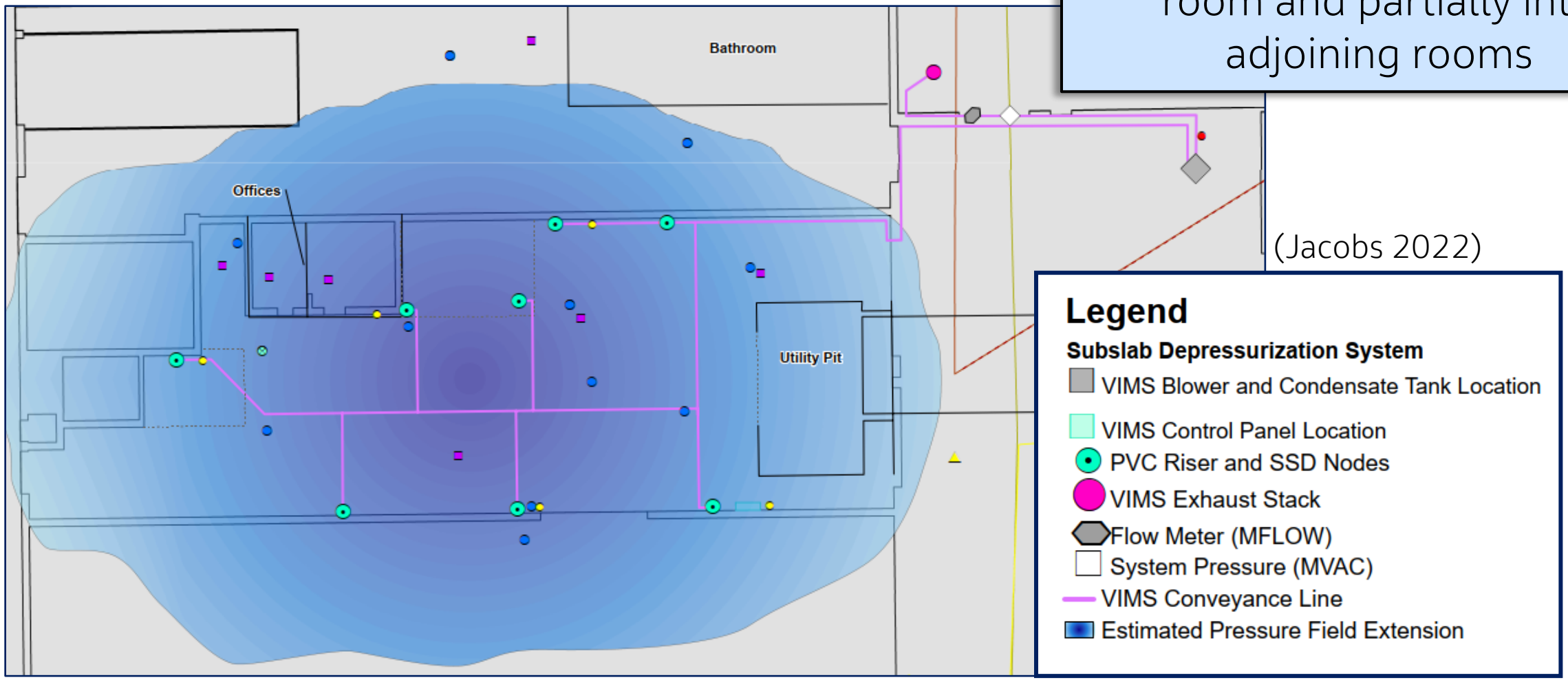
Flux Chamber



Concentrations within the flux chamber at the 1-month post-startup event were an order of magnitude lower than observed during baseline event indicating the VIMS is reducing diffusion across the slab

Subslab-to-Indoor dP Readings

Design dP target
(-0.02 inches of water column)
met across entire maintenance
room and partially into
adjoining rooms



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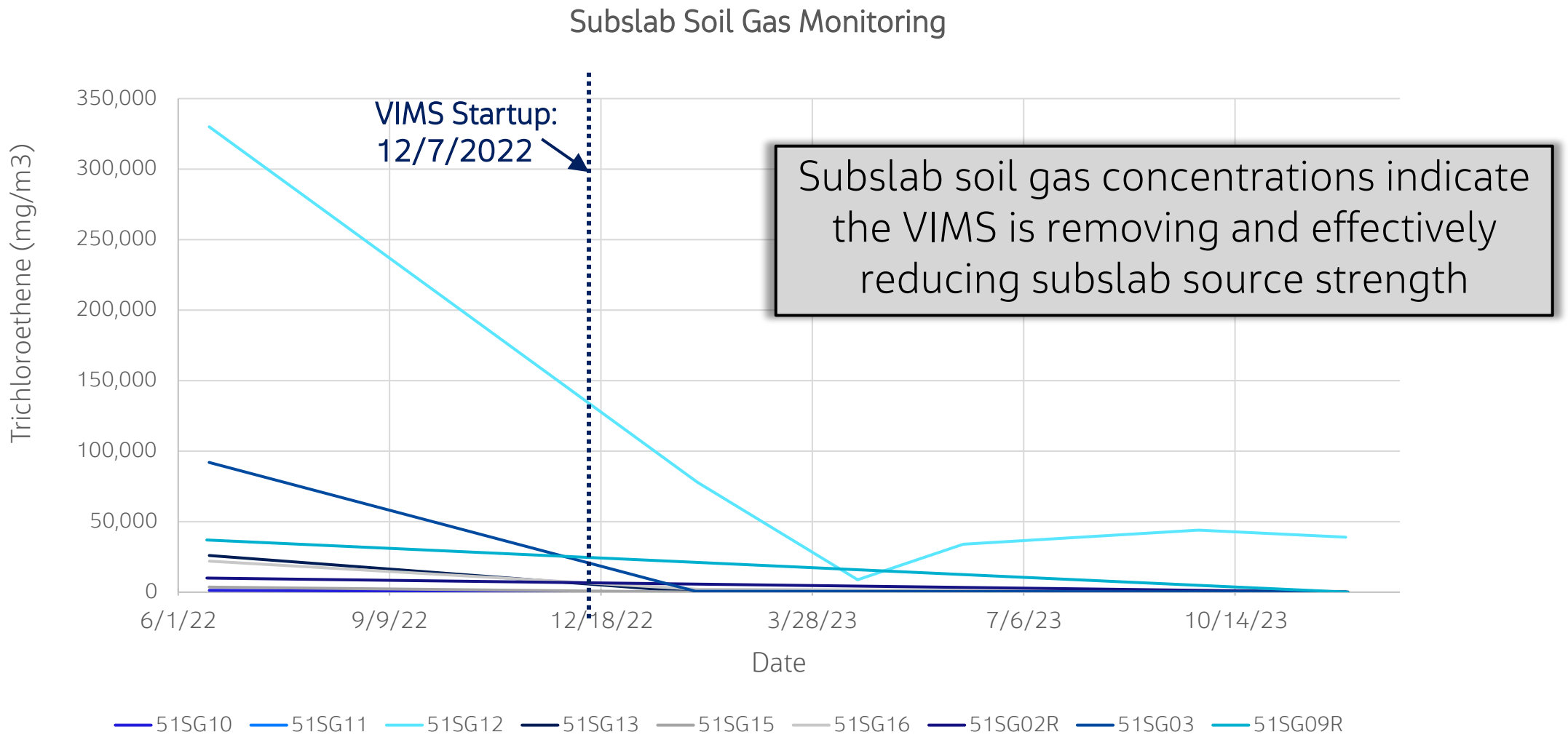
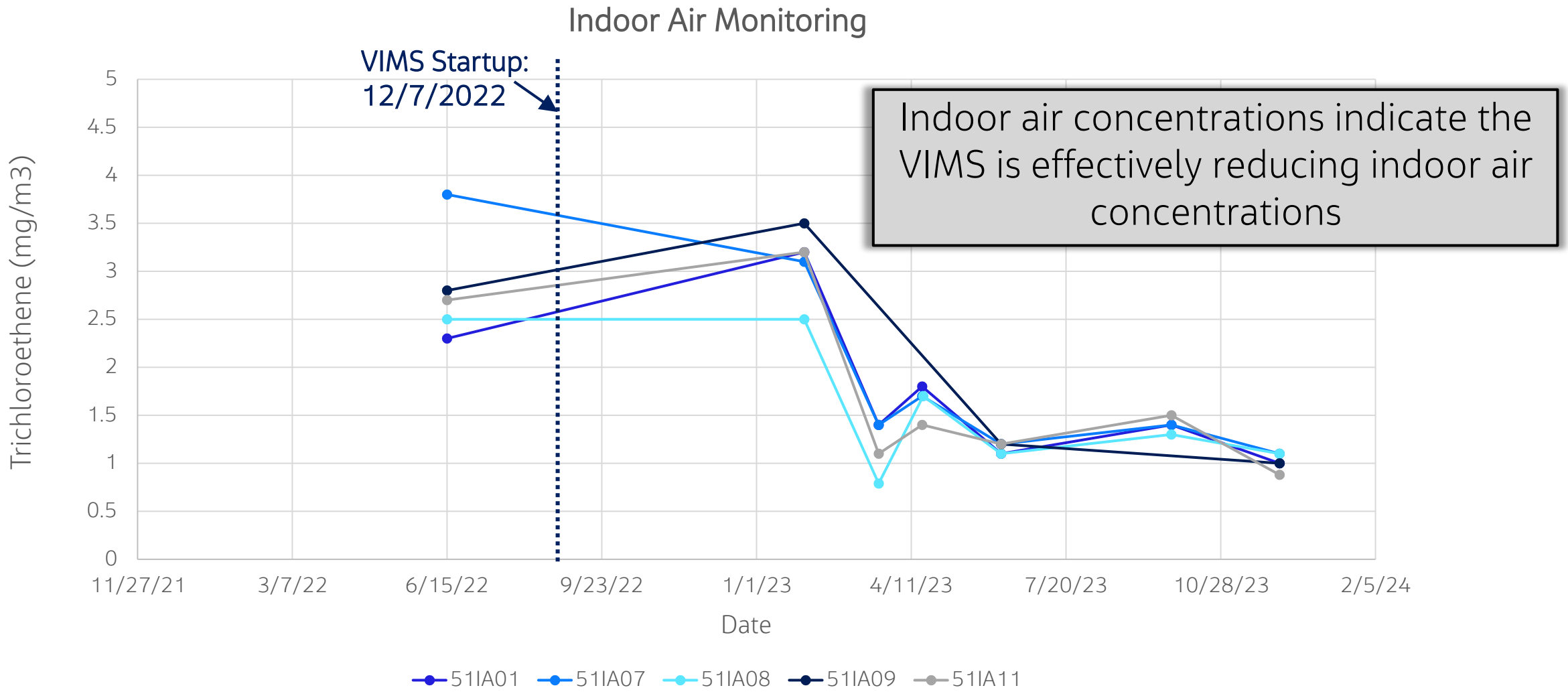
Subslab Soil Gas TCE Concentration Trend



Indoor Air TCE Concentration Trend



Conclusions

- Performance monitoring indicates the VIMS is effectively mitigating the diffusion-driven VI pathway while contributing to subslab source mass removal:
  - Consistently met subslab depressurization target at all locations
  - Helium tracer data indicates a direct connection to the SSD nodes from the most-impacted subslab locations
  - Post-startup BPC testing indicated stable TCE indoor air concentrations and TCE concentrations in the flux chamber at the 1-month post-startup event were an order of magnitude lower than baseline
  - TCE concentrations in subslab soil gas declined by 2-3 orders of magnitude during the first year of operation
  - Indoor air TCE concentrations show a declining trend from baseline and are below target levels
  - The dP, helium tracer, subslab vapor, and indoor air data indicate the SSD system operating as designed to mitigate the VI pathway

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