Evaluating and Quantifying Vapor Intrusion through Preferential Migration Routes and Points of Entry into Buildings

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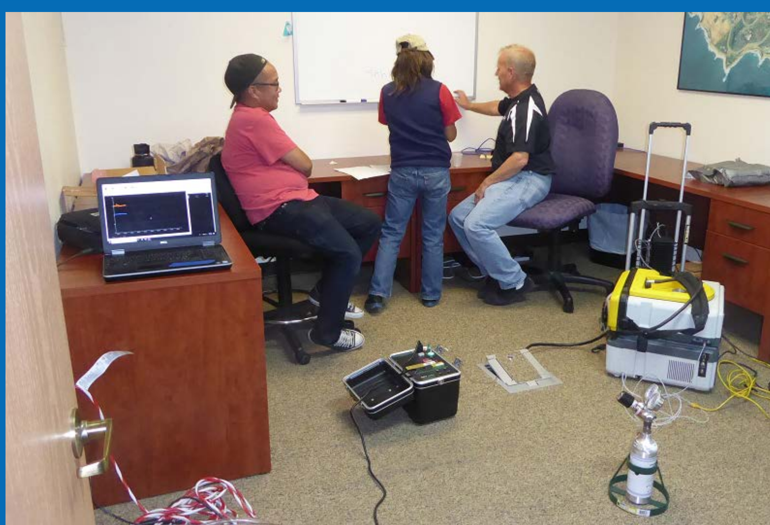

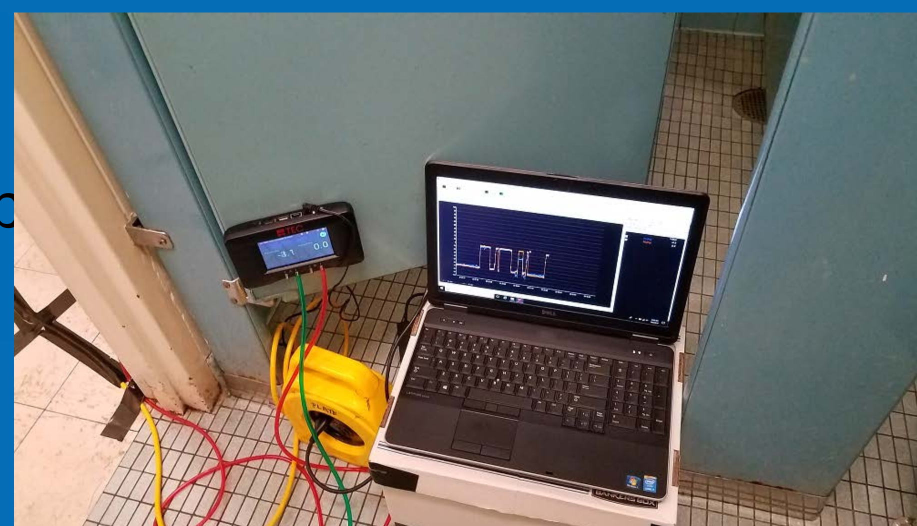

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Preferential Pathways

- We've talked about <u>temporal</u> and <u>spatial</u> variations as they affect vapor intrusion potential

- The third major influence of vapor intrusion is through **Preferential Pathways** into buildings or residences:
  - For example, sewers or utility tunnels can be a significant concern when they pass directly through contaminated groundwater or vadose zone non-aqueous phase liquid (NAPL) sources since those locations could provide the highest concentration infiltration into the conduit. These conduits may be directly connected to the occupied buildings.

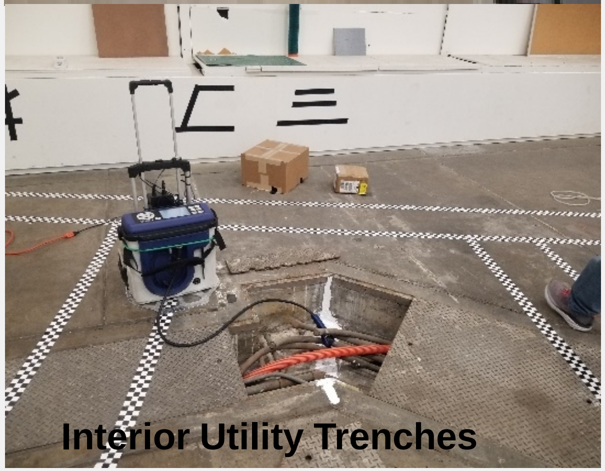
Research Study Goals

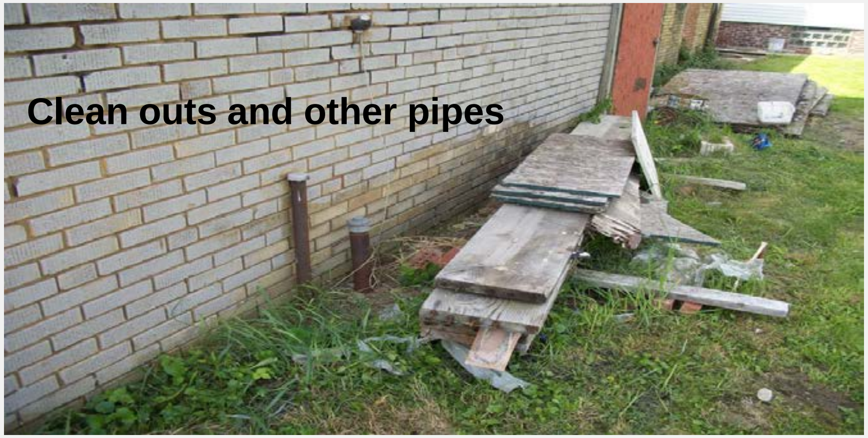
- Identify and use screening methods and tools (e.g., low cost testing of tracers, field portable sensors/instruments, cameras) to rapidly identify if the vapor intrusion pathway is complete.
- Account for the incidence/frequency of occurrence and significance of the potential preferential migration routes to focus vapor intrusion pathway investigations and inform building construction recommendations.
- Identify and test the effectiveness of simple interim mitigation measures taken to minimize or prevent potential exposure from preferential migration routes and vapor intrusion points of entry into the building or residence.
- Quantify and compare the magnitude and percentage of indoor air contamination that can be attributed to each identified preferential migration route into the building.

Research Approach

<u>Initial Assessment / Building Selection</u>

- Assessed existing available data for buildings in Region 9
- Conducted site visits – looking for visible potential preferential pathways





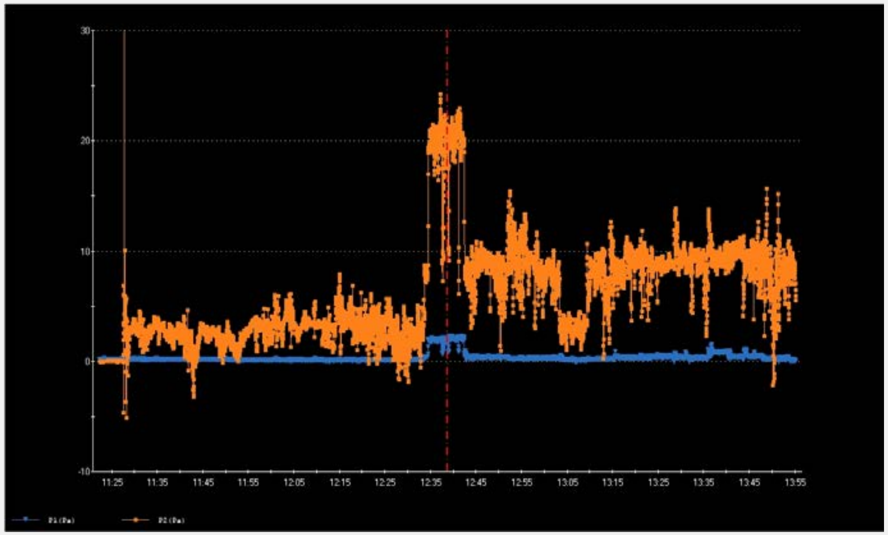
Research Study Approach

Field Measurements / Instruments

- Pressure differential - ΔP
- Portable GC/MS (Gas Chromatograph/Mass Spectrometer)
  - Direct spot readings
  - Overnight continual readings
- Radon detectors
- Helium testing used as simple screening for pathway
- FLIR (Forward Looking Infrared Radar)
- Borescope
- Hot wire anemometer

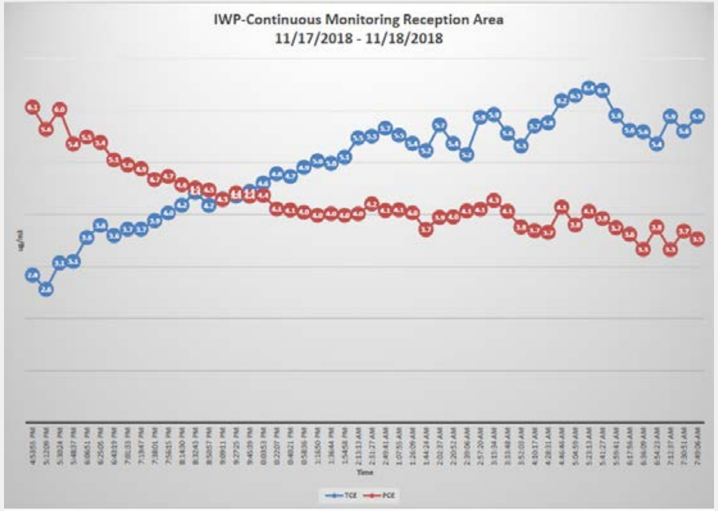
Data Logging Micromanometer

- **Specifications**
  - Dual Gauge
  - Sensitivity <0.1Pa
  - Auto zeroing
- **Cost:** $1,500
- **Uses**
  - Continuous Pressure
  - room/room, room/subslab, room/pathway, or room/outdoor
- **Observations**
  - Essential tool for understanding pathway vapor entry



Portable GC/MS

- **Specifications**
  - Low reporting limits
  - Short runtime
  - Portable (self-powered)
- **Cost:** $150K
- **Uses**
  - Identifying vapor entry
  - Temporal trends
  - Indoor sources
- **Observations**
  - Key to understanding pathway entry
  - Continuous CVOC data is important to assess vapor entry and mitigation



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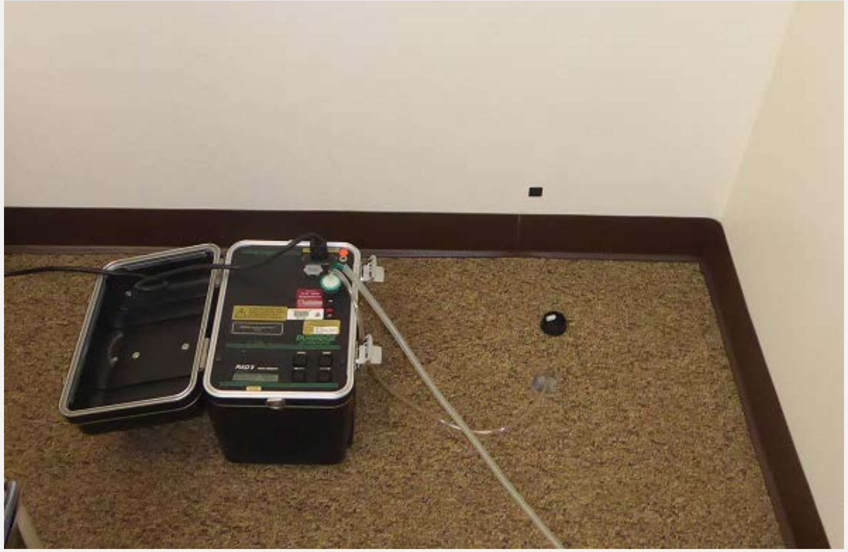
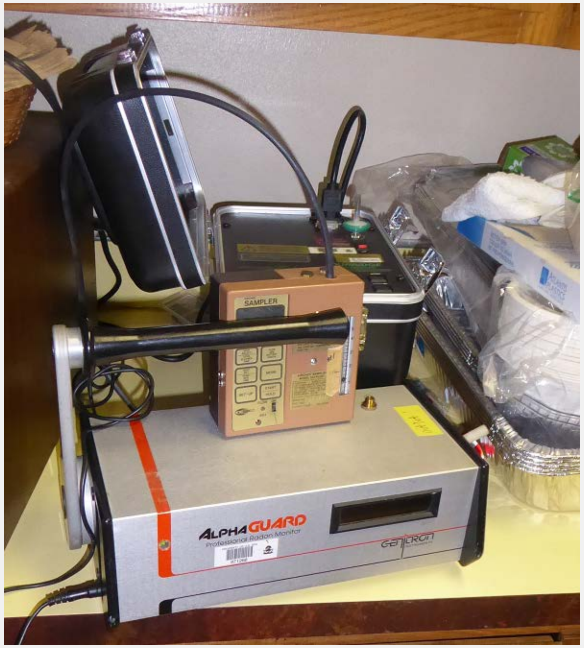
Data Logging Radon Detector

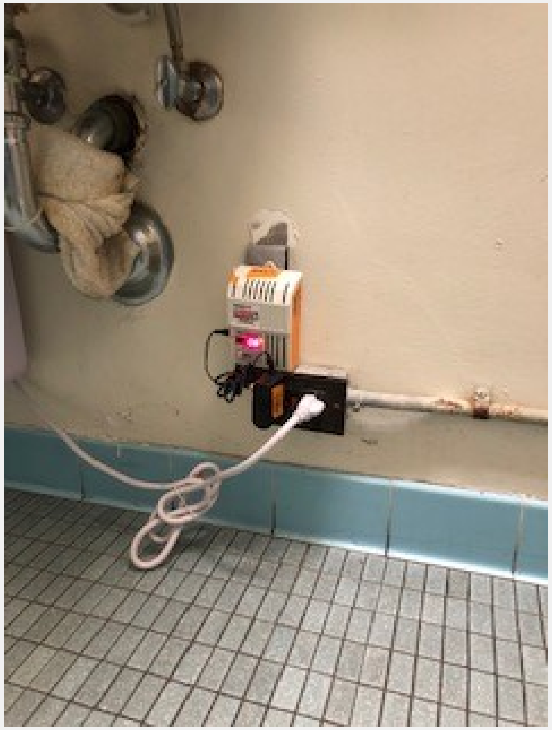
- **Specifications**
  - Detects <1 picocurie/liter (pCi/L)
  - Measurements <1 hr
  - Adjustable sensitivity
- **Cost:** $10K
- **Uses**
  - Identifying higher indoor radon locations
  - Attenuation from sub-slab
- **Observations**
  - Good for collecting sub-slab
  - Long run-times for accurate indoor concentrations
  - Complements longer duration consumer detector





Consumer Radon Detector

- **Specifications**
  - Indoor radon
  - 2 to 7 day and 7+ day
  - Needs to be plugged in
- **Cost:** $125
- **Uses**
  - Spatial radon in a building
  - Temporal radon
  - Surrogate for vapor entry
  - Combine with sub-slab data to determine attenuation
- **Observations**
  - Fair correlation with elevated CVOC vapor intrusion locations
  - Less useful when indoor radon is <0.5 pCi/L



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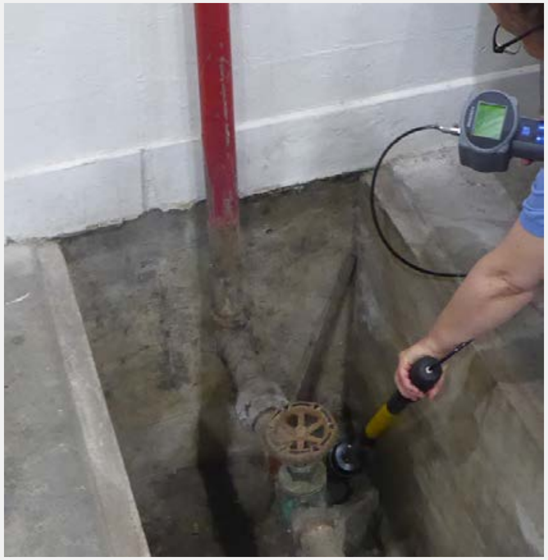
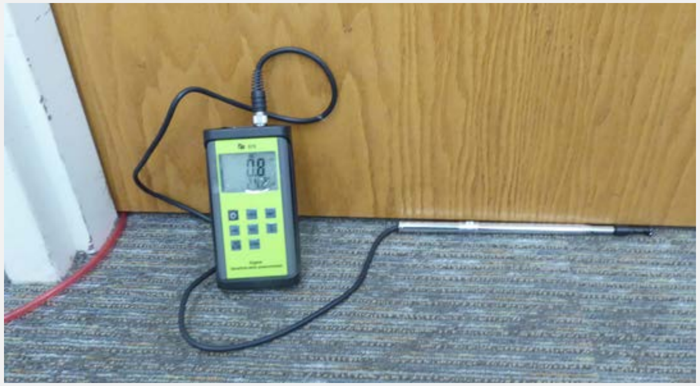
Helium Leak Detection Instrument

- **Specifications**
  - High ppm to percent (%) level range
- **Cost:** $6,000
- **Uses**
  - Tracer for He injection into subslab and pathways
  - Measurement of air exchange rate using He supply and/or decay
- **Observations**
  - Useful to locate novel vapor entry points
  - Due to sensor drift recommend using Tedlar bag samples to conduct exchange rate measurements
  - Requires UHP He ⇨ hard to get



Hot Wire Anemometer

- **Specifications**
  - Duct sensor with probe with speed and temperature sensors
  - Sensitivity 0.2 to 0.5 meters/sec
- **Cost:** $400
- **Uses**
  - Measure air entry from pathways
  - Measure make-up air entry
- **Observations**
  - Hard to characterize flow from many pathways
  - Flow from some pathways below sensitivity of the instrument
  - Limited usefulness without the ability to data-log flow



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FLIR Cameras

- **Specifications**
- **Cost:** $400
- **Uses**
  - Temperature gradients
    - Entry Points
    - Floor to Ceiling (stack forces)
- **Observations**
  - May be helpful to identify known Vapor Intrusion pathways
  - Can identify hidden building structures

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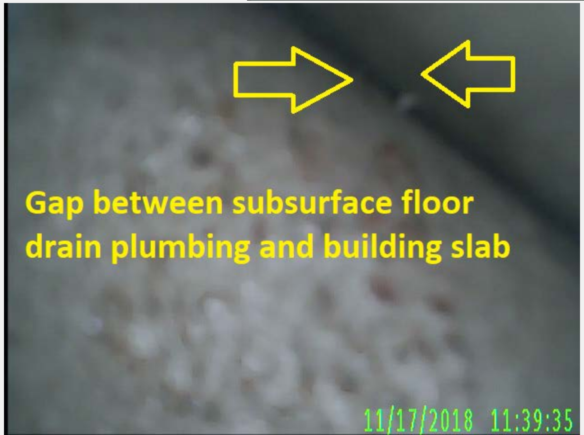
Borescope

- **Specifications**
  - 3-meter length
  - Lighted camera and video
- **Cost:** $130
- **Uses**
  - Observe inside pathways and drains
- **Observations**
  - Good tool to have for certain pathways (plumbing integrity and configuration)
  - Poor picture focus and quality



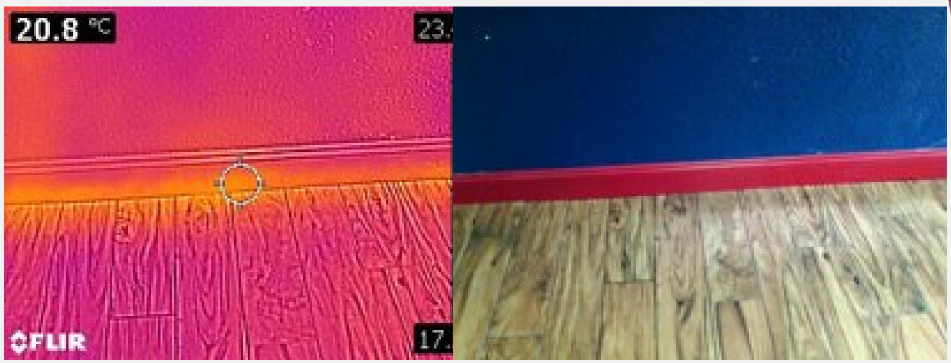
Two Test Buildings - Moffett Field, CA

- <u>Locations Tested/Examined</u>
  - –Building 3
    - General Description
    - Kitchen Restroom

  - –Building 126
    - General Description
    - 2 Restrooms

Building 3

- Scanning Technologies used first to look for preferential pathways
  - FLIR results



  - He results
  - scanning of building locations

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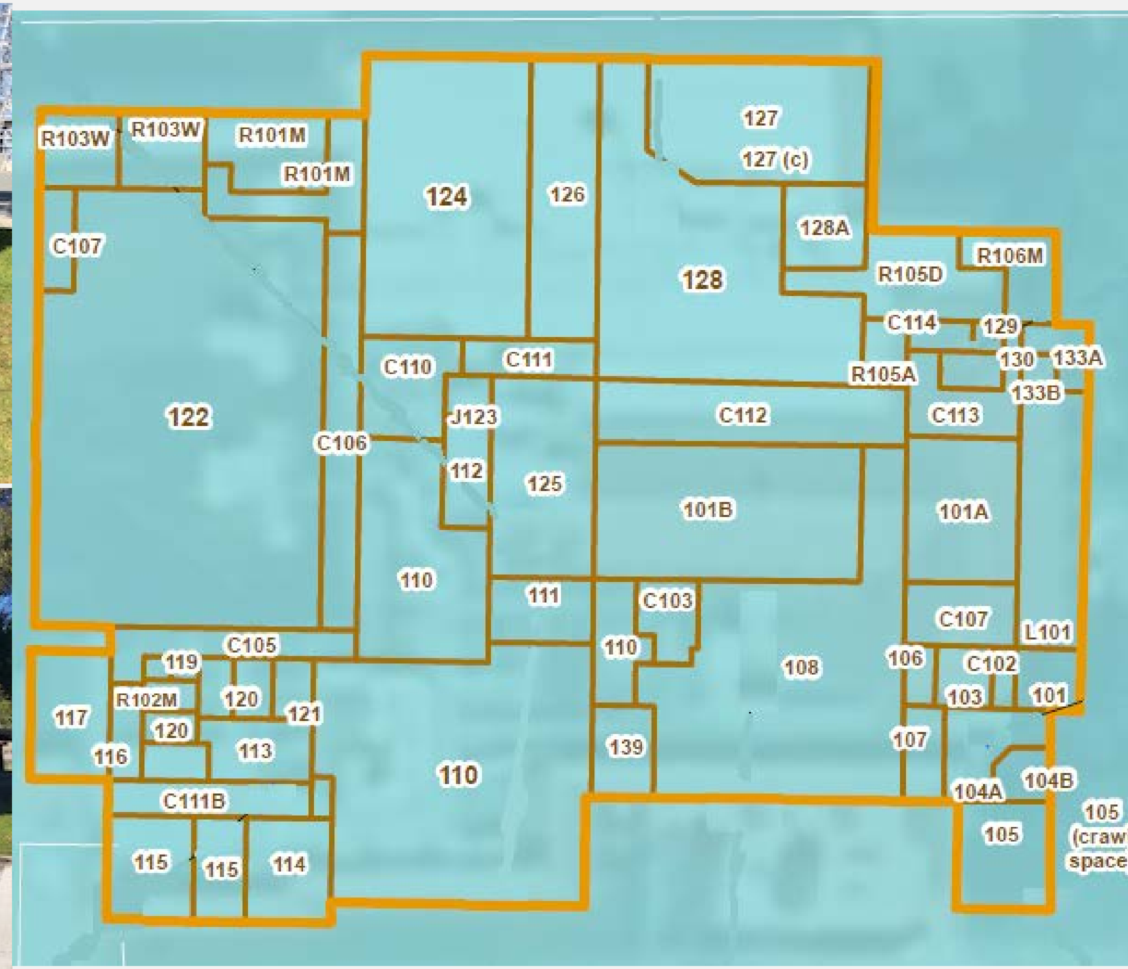
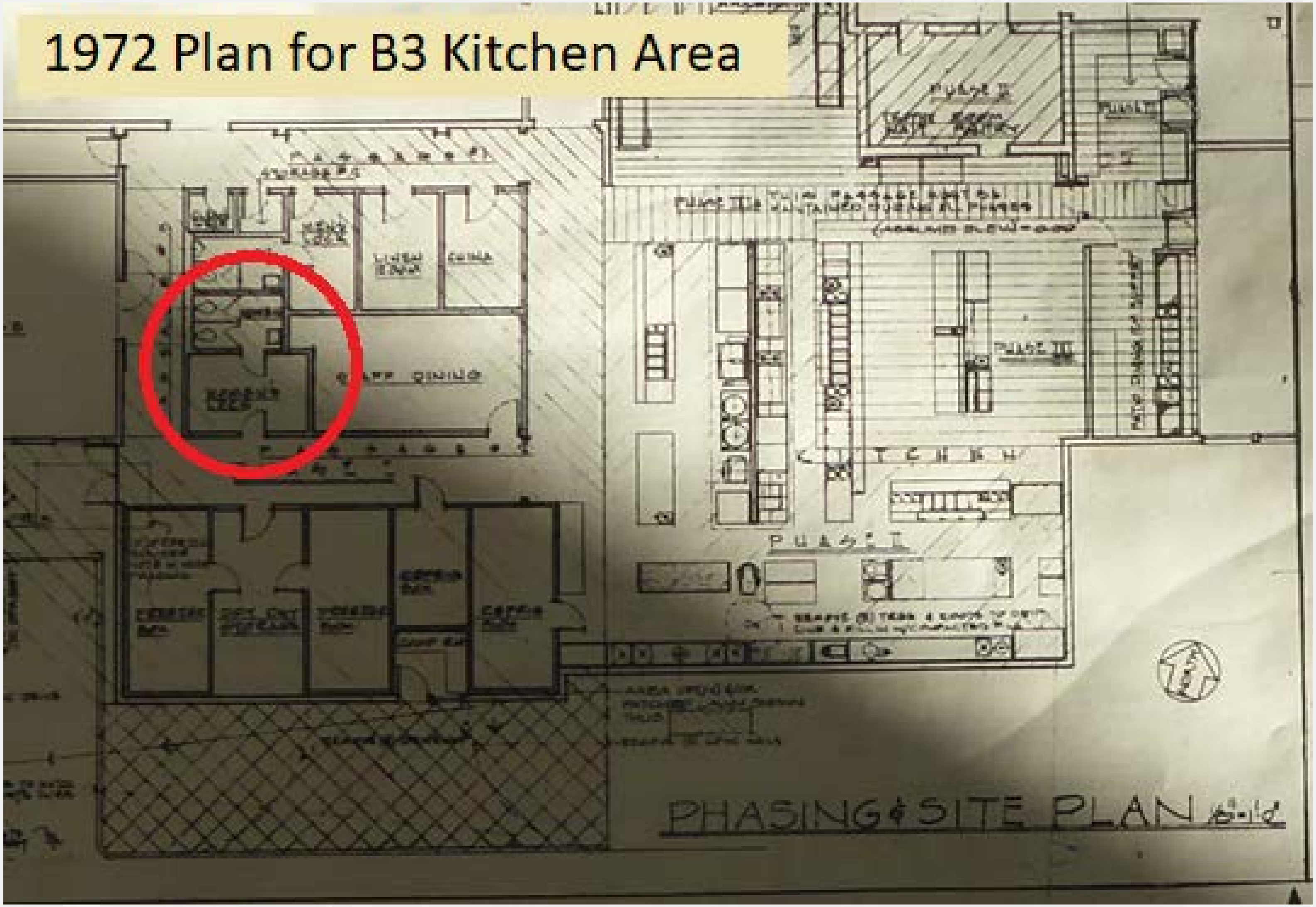
Moffett Field – Building 3

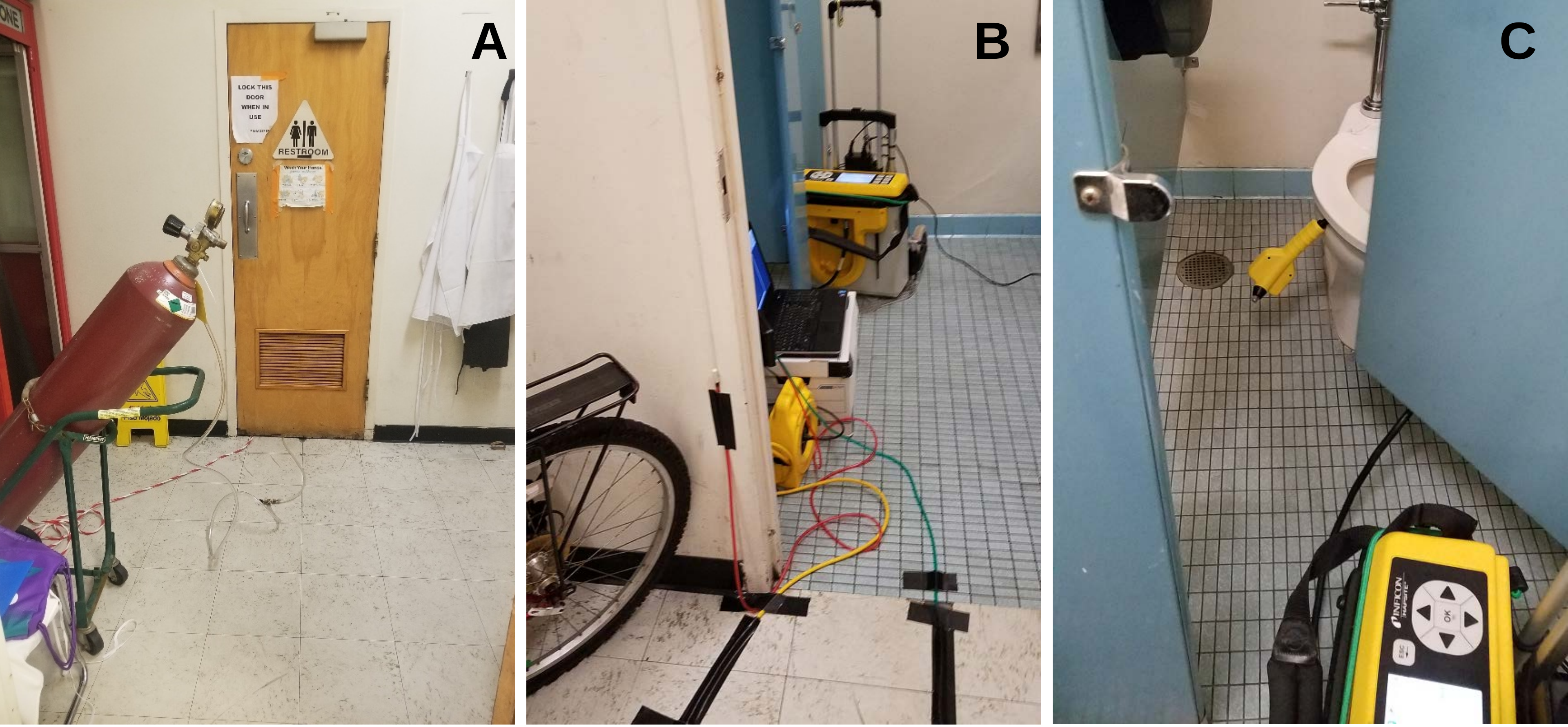


Moffett Field – Building 3

- Building consists of conference center, meeting rooms, café dining room/bar, kitchen, several smaller offices/storage rooms, and public and kitchen employee restrooms
  - Kitchen is large with several areas with grill surfaces and large vent hoods overhead
- After preliminary screening testing and prior data information at Building 3, we focused on the kitchen staff's restroom
  - Restroom area consisted of a locker room and restroom separated by a door

Building 3 - Kitchen Area (1972 Plan)





Building 3 Restroom/Locker Room Layout

- A = Locker room
- B = Restroom
- C = Floor drain

Building 3 - Helium Results

- Helium injected at the sewer clean-out; identified leaking pipes below kitchen sink
- Helium injected in sub-slab port in the locker room; identified migration pathway to old-refrigerator room wall
- Restroom floor drain with drain plug showed no helium detections qualitatively indicating good seal

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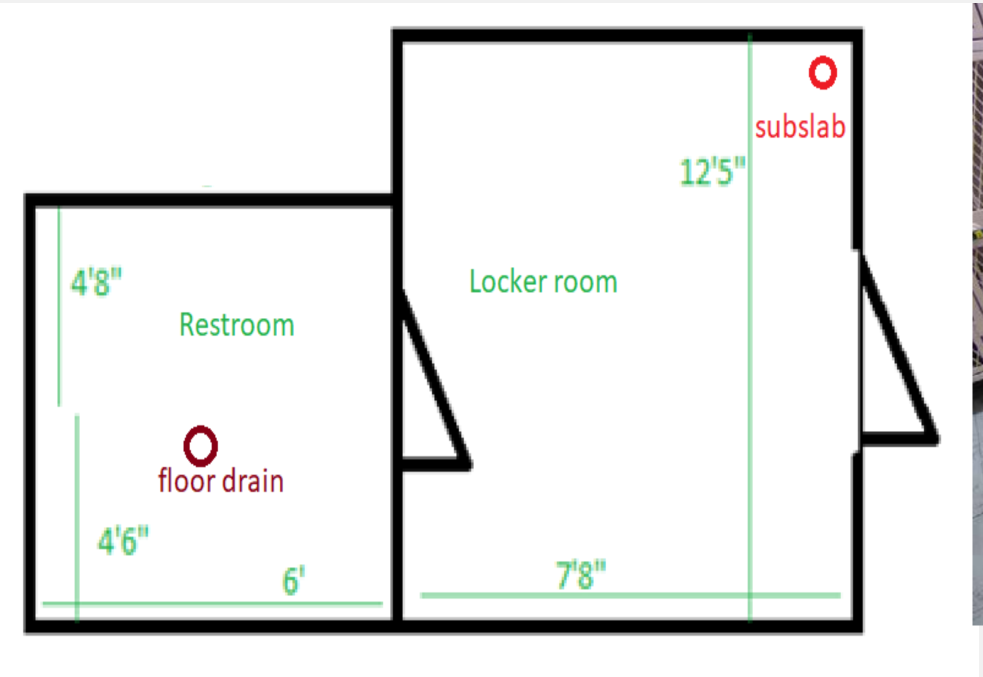
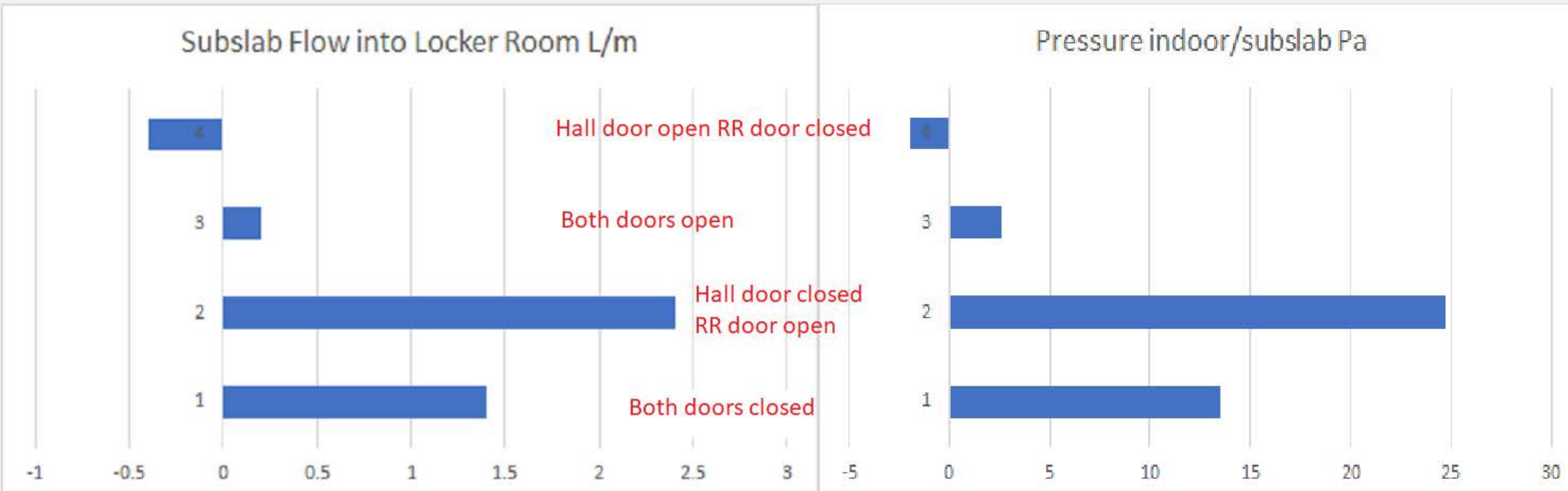
Building 3 - Restroom and Locker Room Differential Pressure Testing



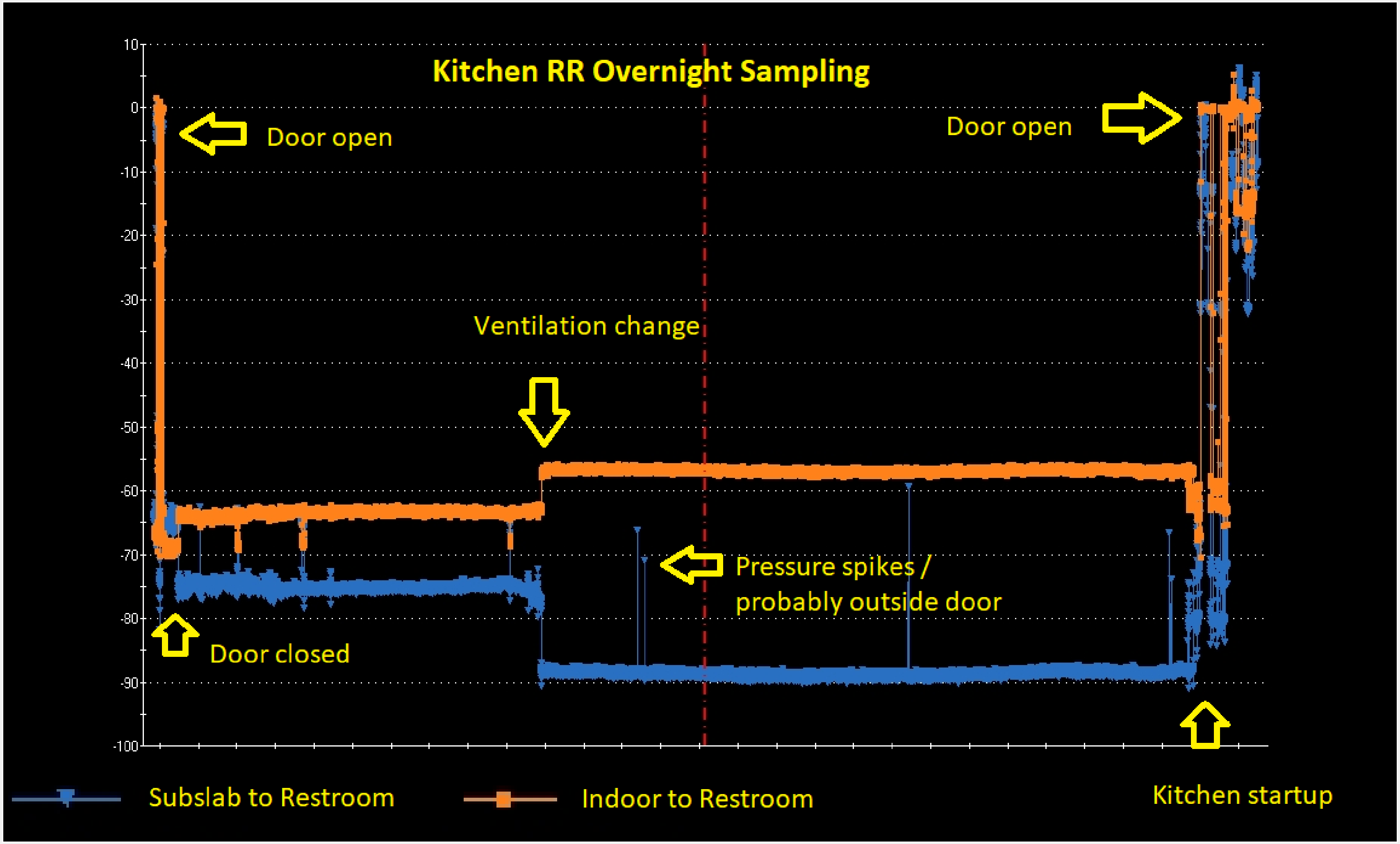
Building 3 - Restroom and Locker Room Differential Pressure Testing

- Pressure/Flow Testing
- Sub-slab port adjacent to the Restroom



- Subsurface flow controlled by the Restroom exhaust fan
- When the Restroom door closed and Locker room door open, air appears to flow into the sub-slab to the Restroom!

Building 3 (Restroom Pressure)



Building 3 - Restroom and Locker Room Differential Pressure Testing

- Pressure Differential testing showed:
  - Strong gradients from hallway through Locker room and into Restroom
    - Gradient influenced by door(s) being opened and closed
    - Conflicting vacuums
- Potential causes
  - Over the grill hoods during operation create vacuum throughout kitchen area
  - In Restroom, to overcome kitchen grill hoods pull, an extra heavy-duty vent fan was installed for the Restroom

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Moffett Field – Building 126

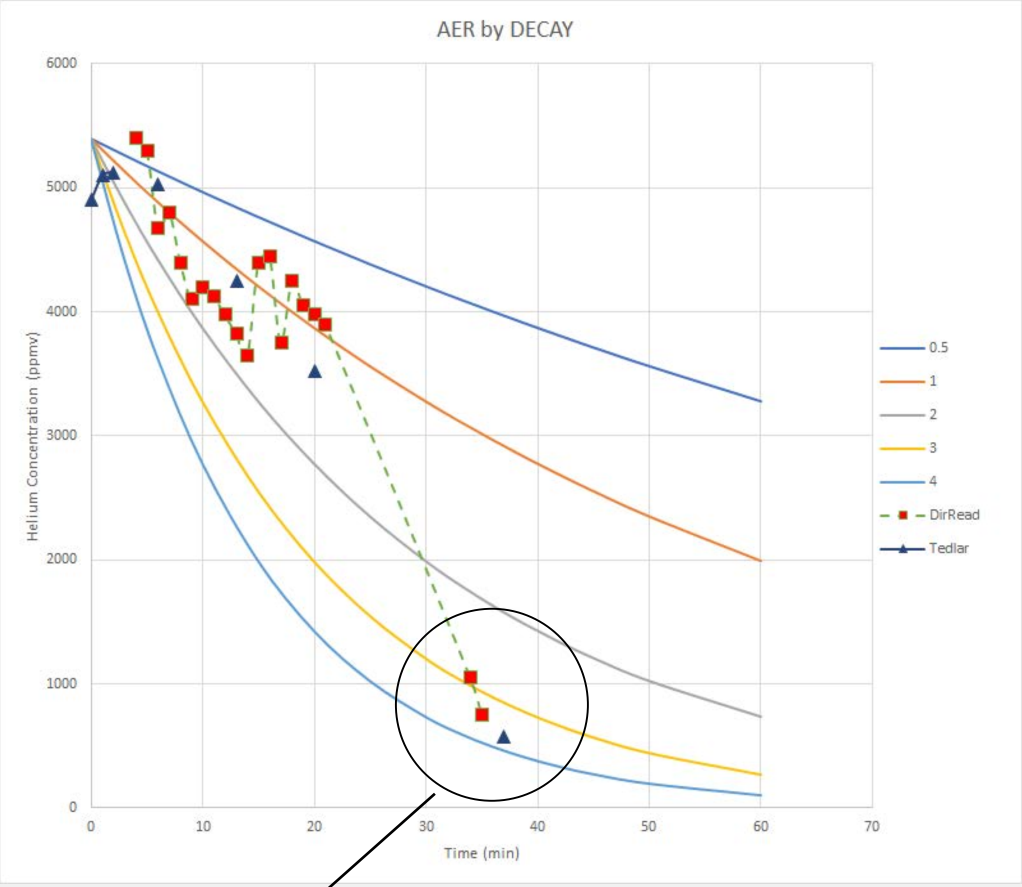
- Museum Building
  - Building consists of several large open-air rooms with displays, back room with train display, and two restrooms
  - Back room and Restrooms may have been added post original building construction as have utility corridor down the building length between 2 areas

Building 126 - Layout

Building 126 Restrooms

Building 126 - Air Exchange Rate (AER)

- AER in the Restroom
  - Using helium as tracer
  - Injected and mixed
  - Collected air samples in Tedlar bags



– Y-axis = He ppmv
– X-axis = time (min)
– Red squares direct readings
– Blue triangles Tedlar bags
– Continuous curves = modeled AER by decay

Restroom door was opened

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Building 126 – Helium Survey

- Helium was injected in:
  - Sewer clean-out by the sink in Restroom
    - Identify if utility lines are leaking gases into indoor air
  - Sub-slab port by the Utility Corridor door wall
    - Identify potential cracks nearby
    - Preferential pathways through utility lines (electrical, phone, etc)
    - Preferential pathways through backfill of drain through the restroom

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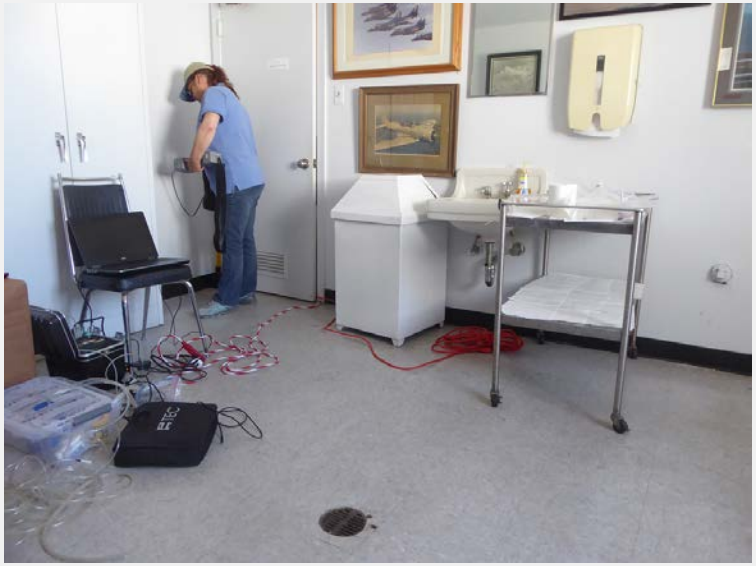
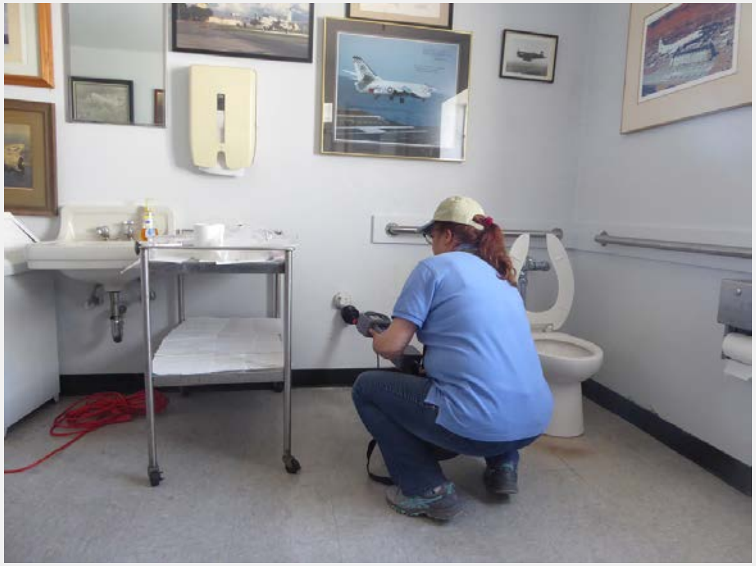
Building 126 – Restrooms 1 & 2 Helium Surveying



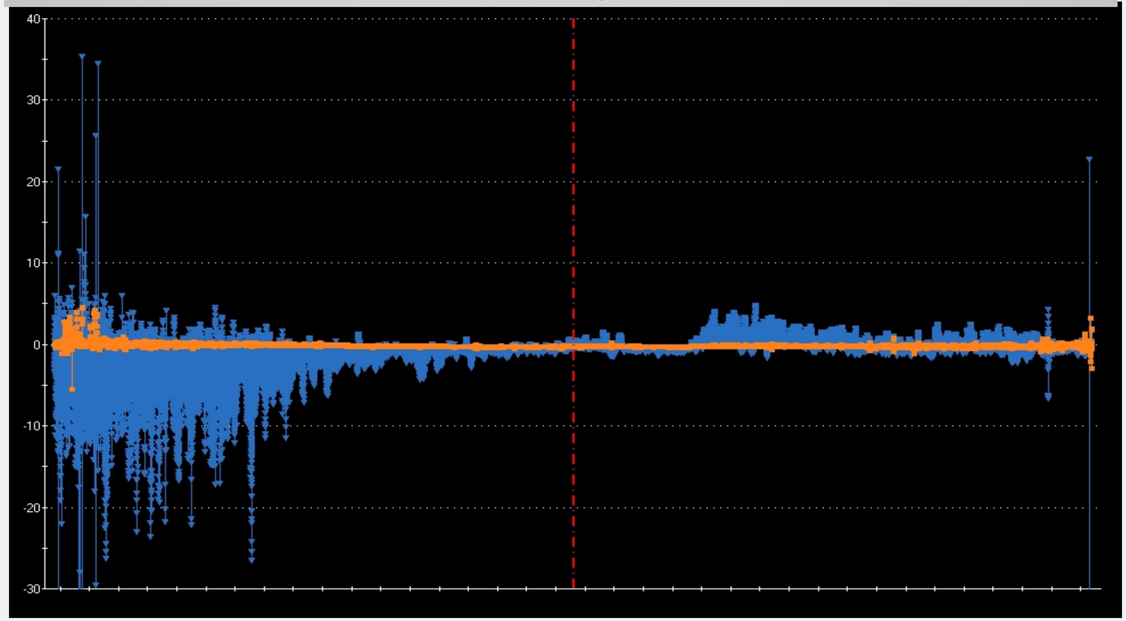


Restroom 1- CVOC and Pressure

- Red - PCE
- Blue - TCE
- Purple - Grab pressure

May 2019 Day 1 RR1 Overnight Sampling

- Orange - indoor/subslab
- Blue - indoor/outdoor



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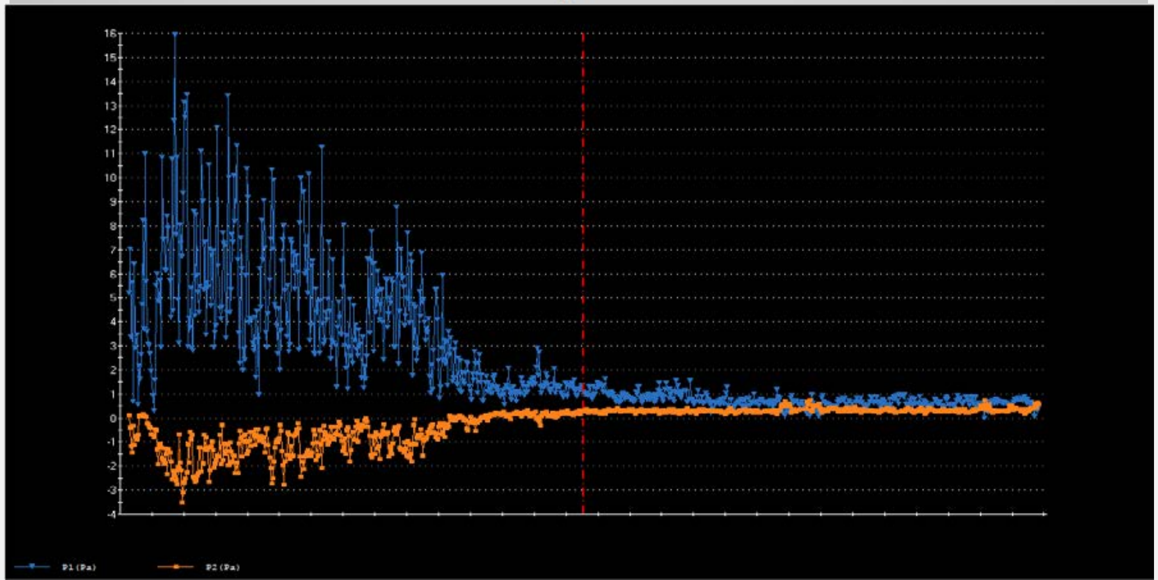
Restroom 2 - CVOC and Pressure

- Red - PCE
- Blue - TCE
- Purple - Grab pressure

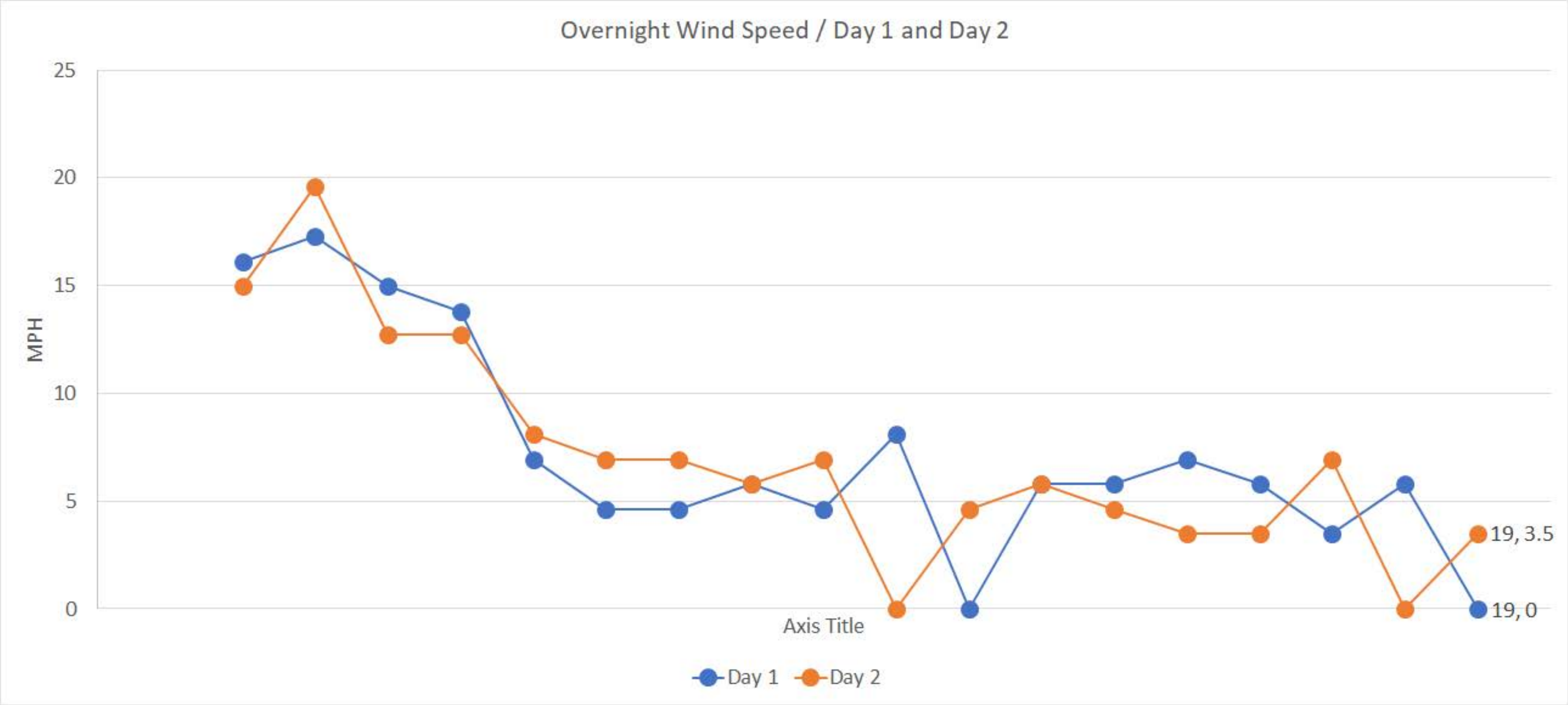
May 2019 Day 2 RR2 Overnight Sampling

- Orange - indoor/sub-slab
- Blue - outdoor/ indoor



Restroom CVOC and Pressure

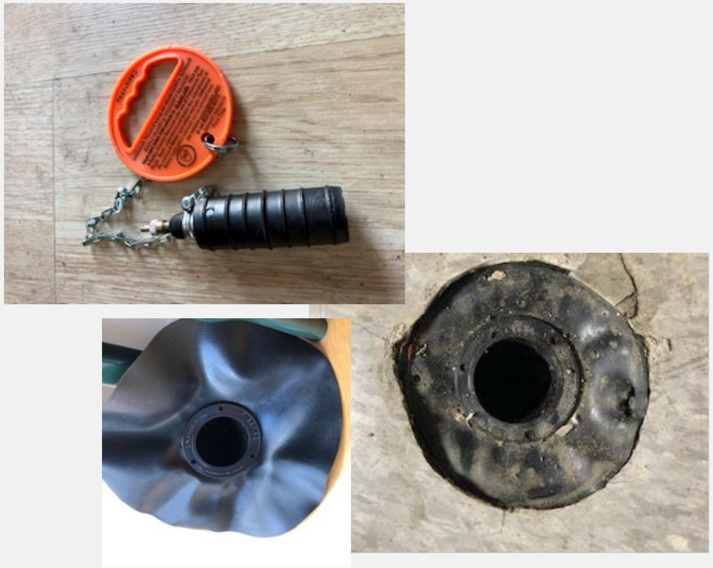
May 2019 Wind Speeds – Overnight - 4pm Day 1 to 9am Day 2



Appears to be correlation between wind and indoor pressure and CVOC concentrations – Further analysis needed

Building 126 – Helium Survey Results

- Response from helium injected in sub-slab port in the Restroom identified cracks on the concrete on utility hall (those were later mitigated by sealant).
- The Restroom floor drains tested with drain plugs showed no helium detections, indicating a good seal
- No helium response inside the rooms when helium injected in the sewer clean-out indicating pipes not leaking



Very Very Preliminary Findings – R9/ORD Study (*please, don't quote or cite ☺*)

- Indicator, Tracer, Surrogate (ITS) Tools
  - Continuous pressure differential and CVOC measurements served as powerful aids to understanding vapor intrusion pathways
  - Helium testing useful in identifying potential preferential pathways but not readily implementable in field
  - Other ITS tools we tested enhanced our understanding of vapor intrusion and provided ancillary *indicators* of preferential pathways

R9/ORD Study – Very Preliminary Findings

- Temporal Trends
  - Diurnal cycles of weather and building ventilation can have significant impacts on pathway entry and should be measured to improve mitigation decisions and increase understanding of vapor intrusion potential
    - *Building 126 influence of wind on building envelope*
  - Building mechanics can play a major role in vapor intrusion potential through preferential pathways
    - *Building 3 ventilation systems*