Cross Foundation Differential Pressure and Temperature Impacts on Vapor Intrusion at Two Buildings

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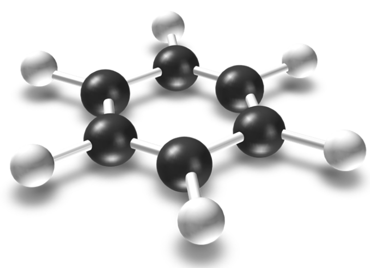
Presentation Outline

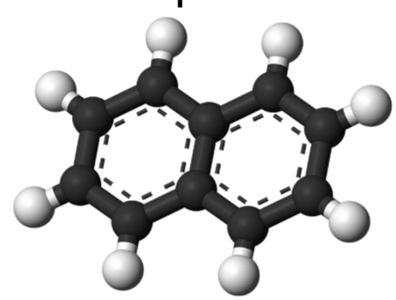
- Briefly Describe the Challenges of Predicting/Measuring Vapor Intrusion
- Discuss Testing Protocol Utilized
- Describe the 2 Subject Buildings and Test Locations
- Collected Data Summary
- Lessons Learned
- Questions

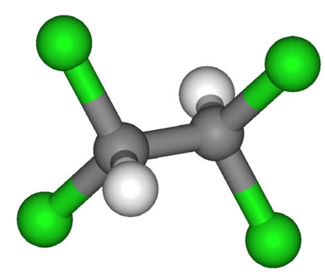
What is Vapor Intrusion?

- Vapor intrusion occurs when there is a migration of vapor-forming chemicals from any subsurface source into an overlying building. (EPA Vapor Intrusion Web Site)

- Volatile Chemicals in the Groundwater and Soil Gas Near and Beneath Buildings Can Enter (Intrude) into the Building, Potentially Causing Unacceptable Volatile Chemical Concentrations in the Air Being Respirated by the Occupants.







Measuring Vapor Intrusion Is Difficult

Indoor Air Quality Alone Does Not Provide Definitive Proof

- Many of the Volatile Chemicals of Interest are Present in Common Products in Buildings.
  - Carpets - Flooring - Furniture - Paints
  - Hobby Supplies - Cleaning Products - Sports Equipment - Decorations
- Cannot "Separate" Soil Vapor Intrusion Molecules from Building Materials Molecules
- There Can be a High Degree of Variation in Volatile Chemical Concentrations in Indoor Air Over Multiple Sampling Events

Potential Vapor Intrusion Risk Estimation

What Concentration of Volatile Chemical is Needed Near a Foundation to Potentially Impact Indoor Air?

It Depends….on many variables

Chemical Phase	Building Construction	Basement or Slab
Source Volume	HVAC Operation	Occupation Frequency
Distance to Building	Foundation Condition	Barometric Pressure
Temperature	Utility Entrances	Wind
Presence of Frost	Depth to Groundwater	Time of Year

Potential Vapor Intrusion Risk Estimation

Regulators Utilize VI Models to Develop Soil Gas Concentration Screening Levels to Determine Potential Risk of Vapor Intrusion

- Screening Models Used are Relatively Simple Assuming:
  - Steady State
  - An Infinite Source of Contamination Exists
  - Air Mixing in the Building is Uniform
  - Preferential Pathways do not Exist
  - Biodegradation of Soil Gas Does Not Occur
  - Contaminants are Homogeneously Distributed Beneath the Building
  - Contaminant Vapors Enter the Building Primarily Through Cracks in the Foundation and Walls
  - Ventilation Rates and Soil Gas Flow into the Building are Assumed to Remain Constant

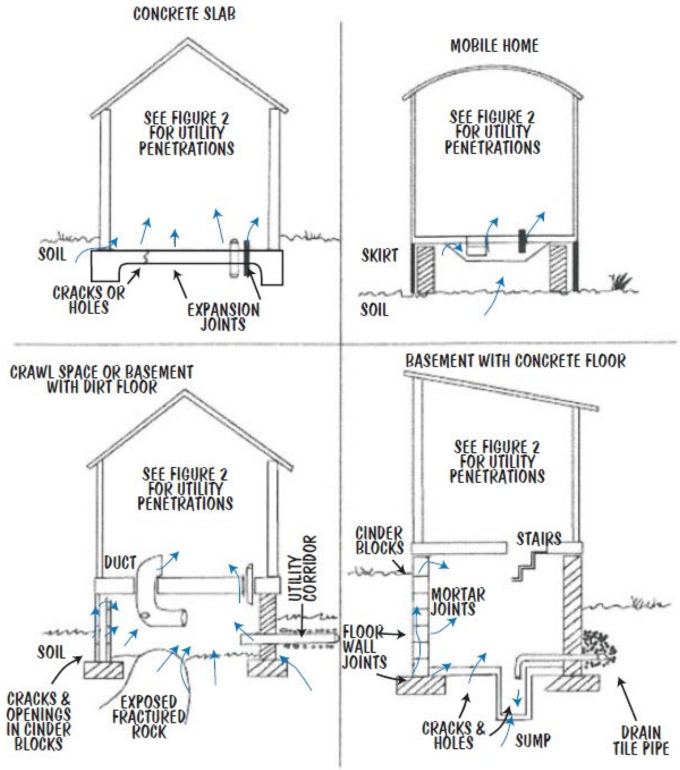
Can Soil Gas Potentially Flow Into the Building?

- Soil Gas Enters Building Via Advection
  - Darcy – Flow Rate = Area x Permeability x Gradient

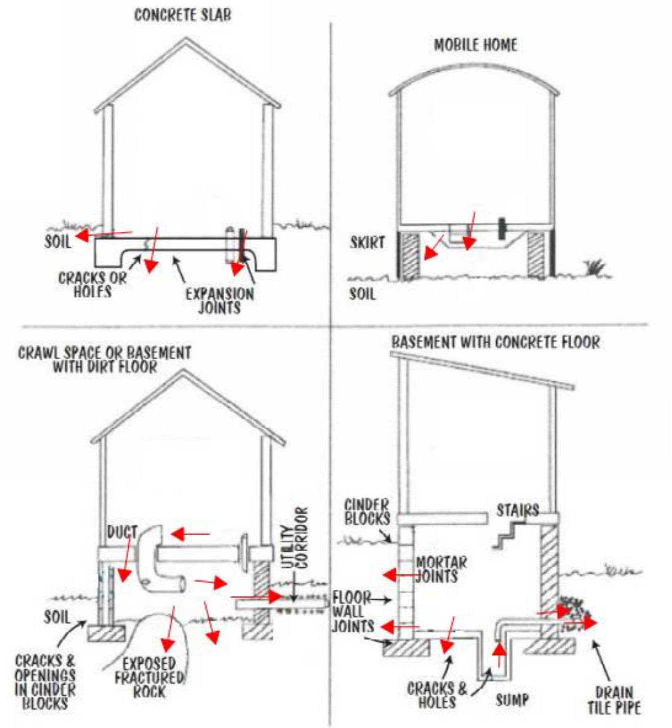
- Direction of Soil Gas Flow In/Out of a Building is Dependent on the Pressure Differential Between Soil Gas and Adjacent Indoor Air Space

- Positive Differential Pressure Needed for Soil Gas Flow into Building

- Negative Differential Pressure Needed for Indoor Air Flow into Soil



Positive Differential Pressure
Soil to Indoor Air



Negative Differential Pressure
Indoor Air to Soil

EPA, 2008

Study Design

- Monitored Indoor Air Quality and Differential Pressures at 2 Buildings of Differing Construction for 1 to 2 weeks
  - Known Soil Vapor Intrusion Impacts (PCE)
  - Unoccupied During Study, with HVAC Operating
  - Collected Daily Samples of Indoor Air Using 24hr Summa Cannisters
  - Utilized Pressure/Temperature Dataloggers to Collect Data Every 15 Minutes
    - Subslab, Basement, 1st Floor, Outside
  - Normalized datalogger data to barometric pressure readings from on Site Weather Station
  - Evaluated Pressure Differential, Temperature Differentials and Air Quality for Trends

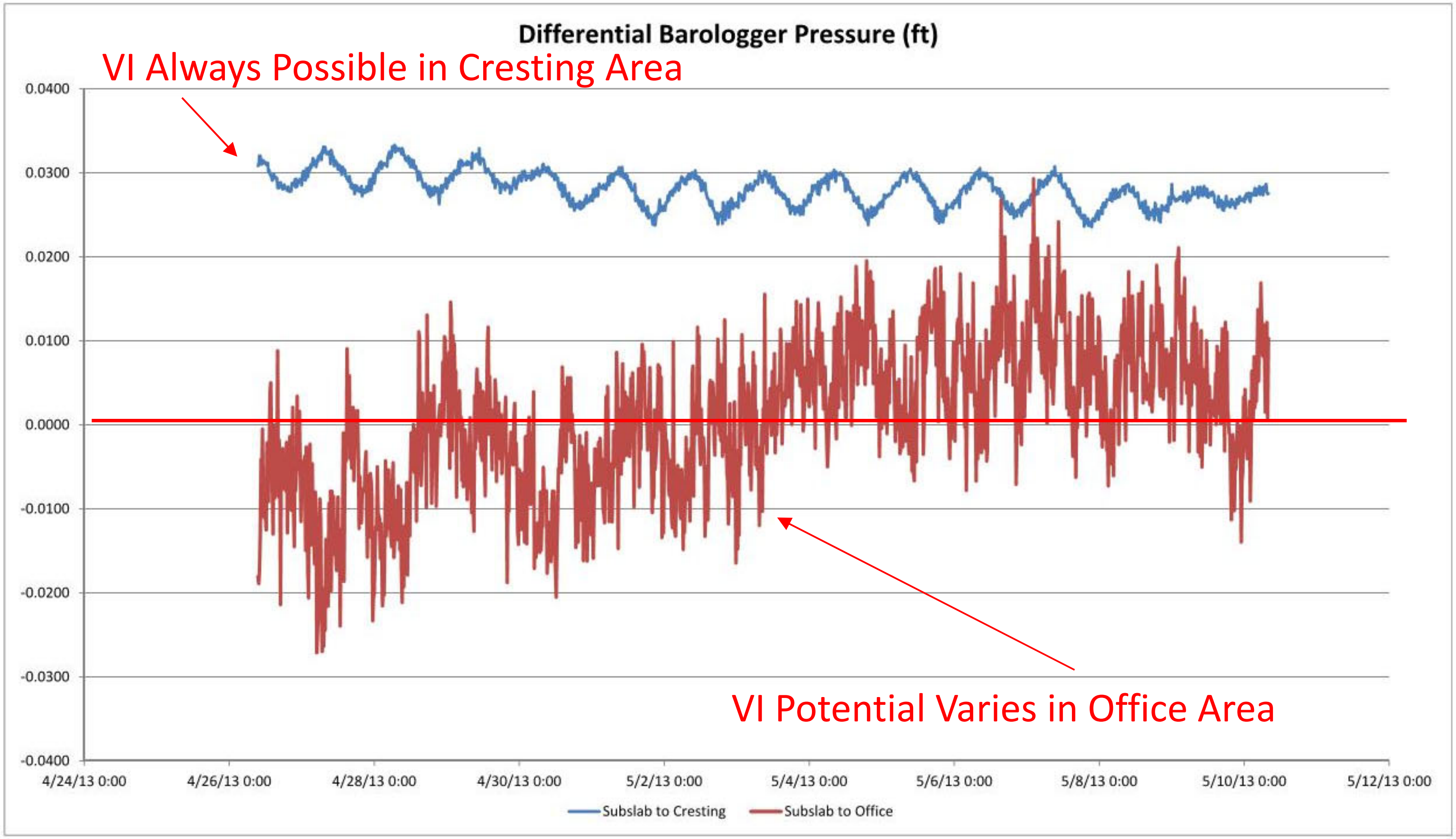
Maska Building

Former Clothing Manufacturer with Industrial Dry Cleaners

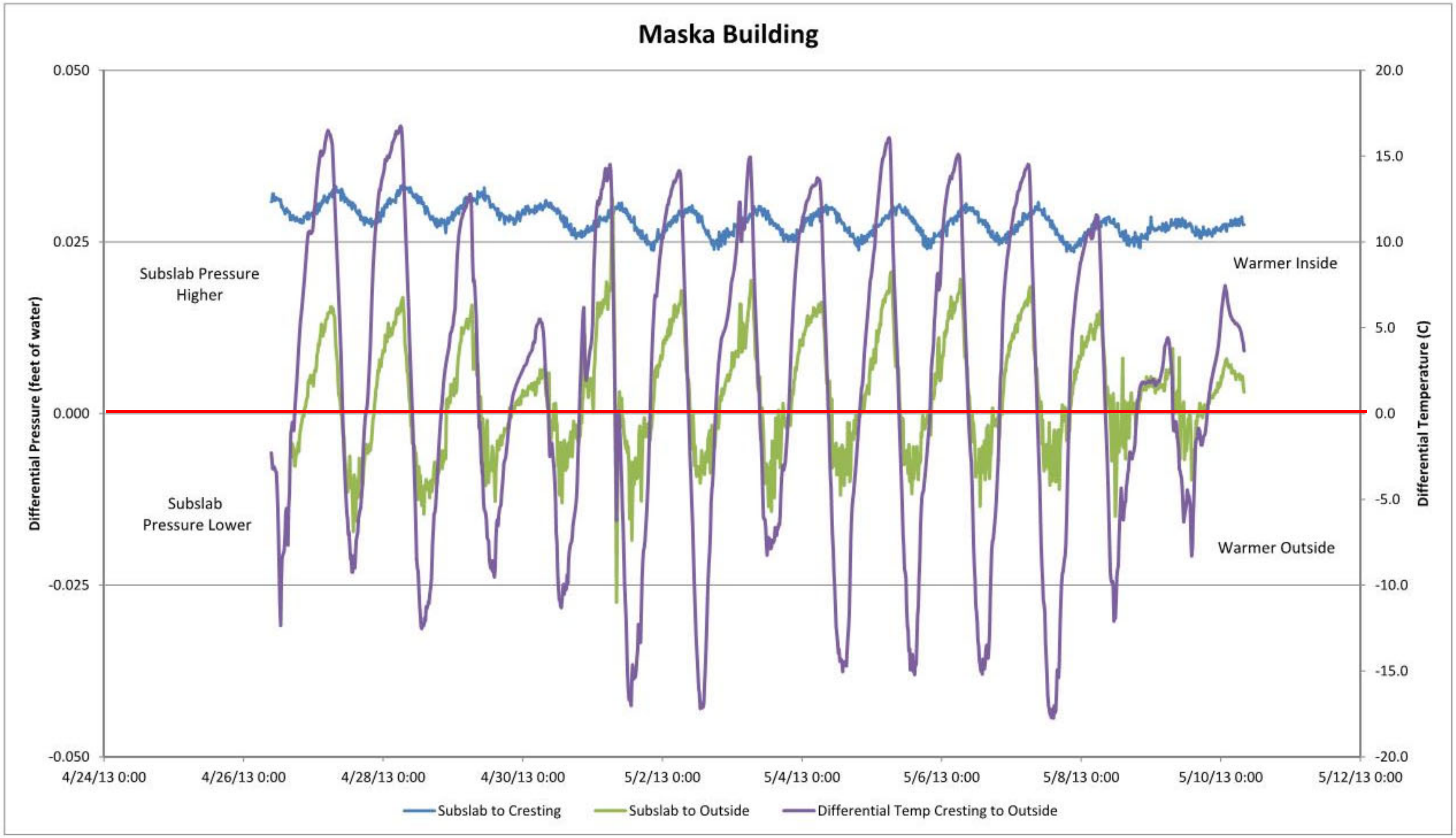
PCE Releases On Site Include

- Wastewater & Still Bottoms to Leachfield
- Dumping
- Spills
- Groundwater 25+ feet

45,000 sq. ft.
Slab on Grade



Differential Barologger Pressure (ft)
VI Always Possible in Cresting Area
VI Potential Varies in Office Area
0.0400
0.0300
0.0200
0.0100
0.0000
-0.0100
-0.0200
-0.0300
-0.0400
4/24/13 0:00
4/26/13 0:00
4/28/13 0:00
4/30/13 0:00
5/2/13 0:00
5/4/13 0:00
5/6/13 0:00
5/8/13 0:00
5/10/13 0:00
5/12/13 0:00
Subslab to Cresting
Subslab to Office



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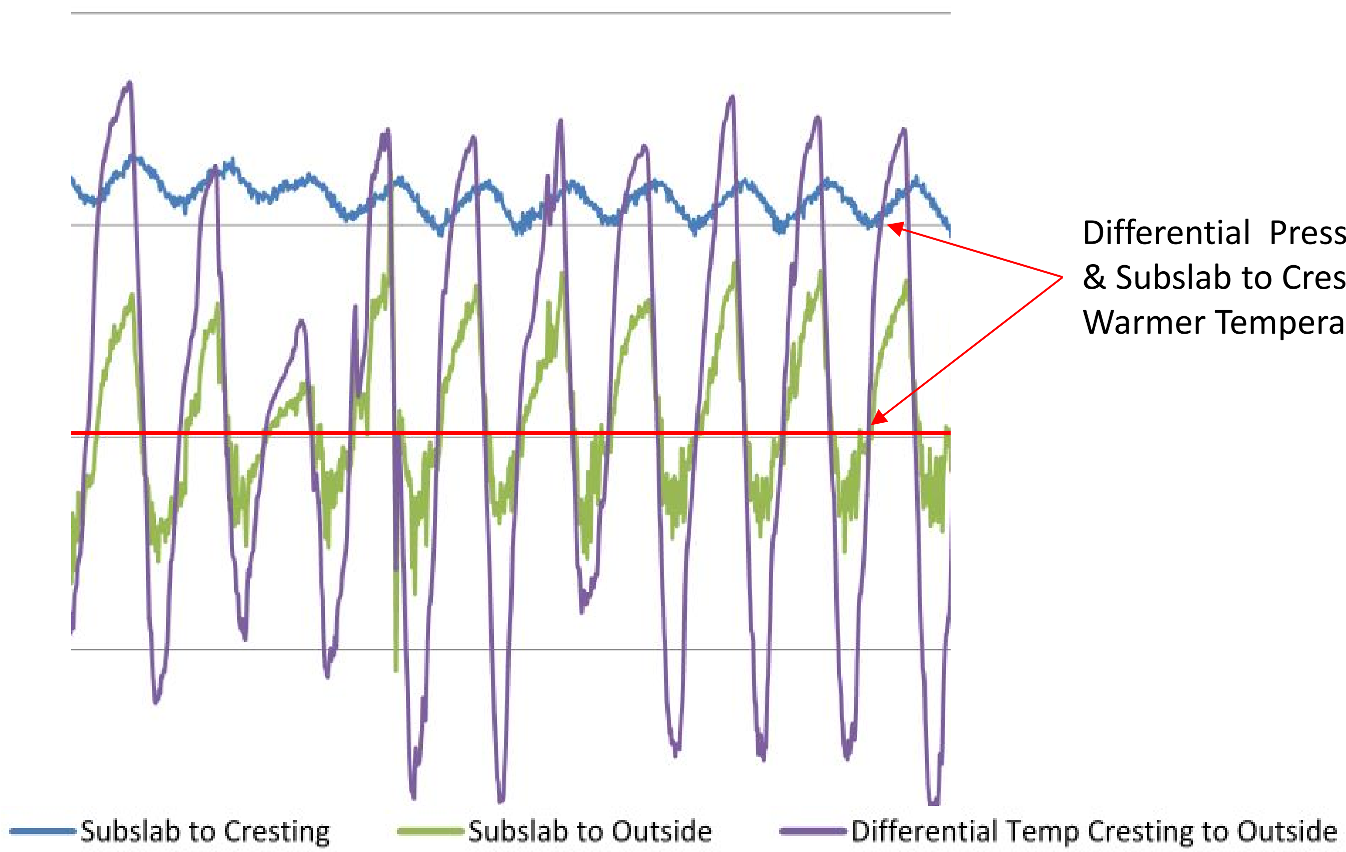
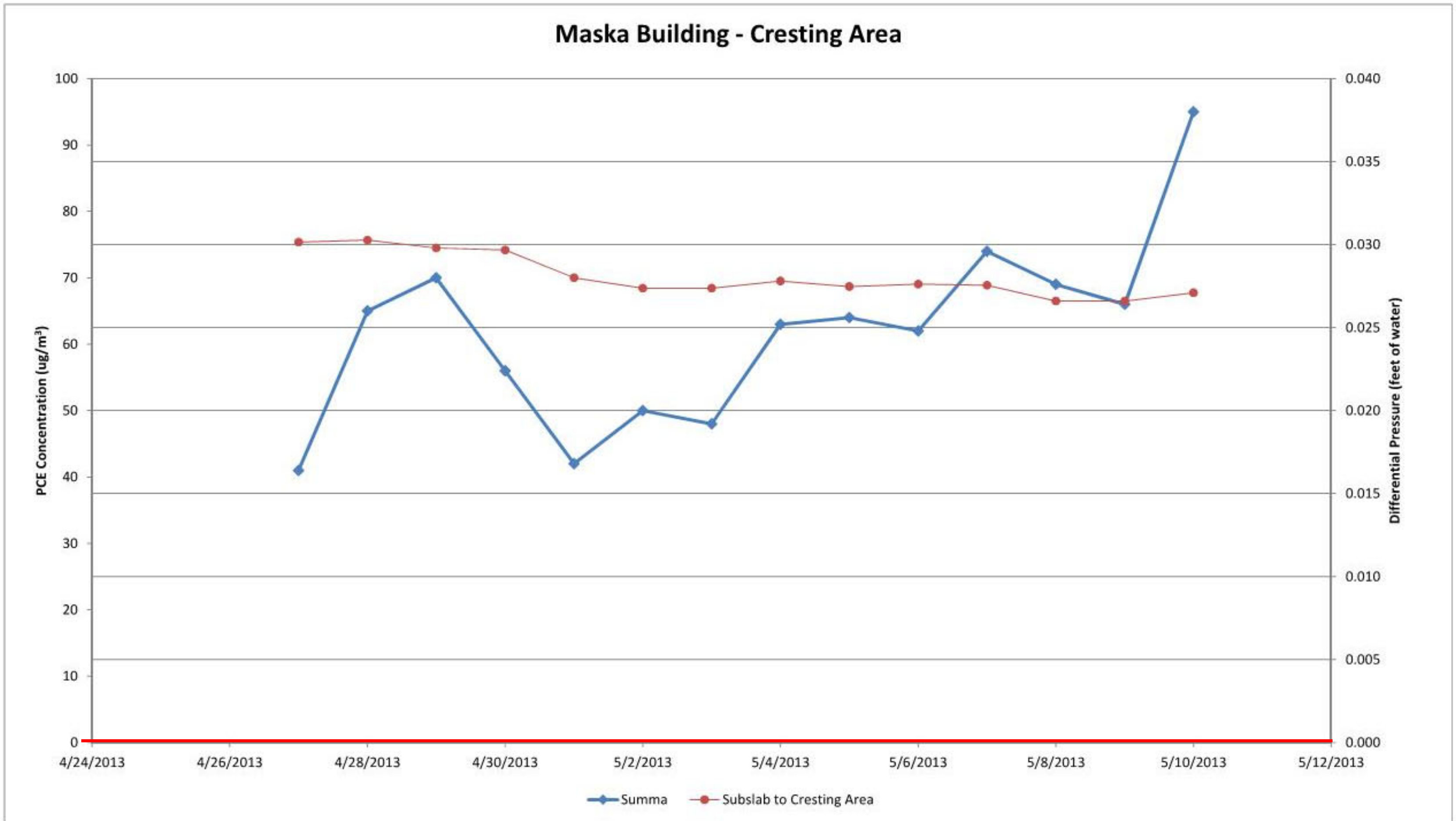
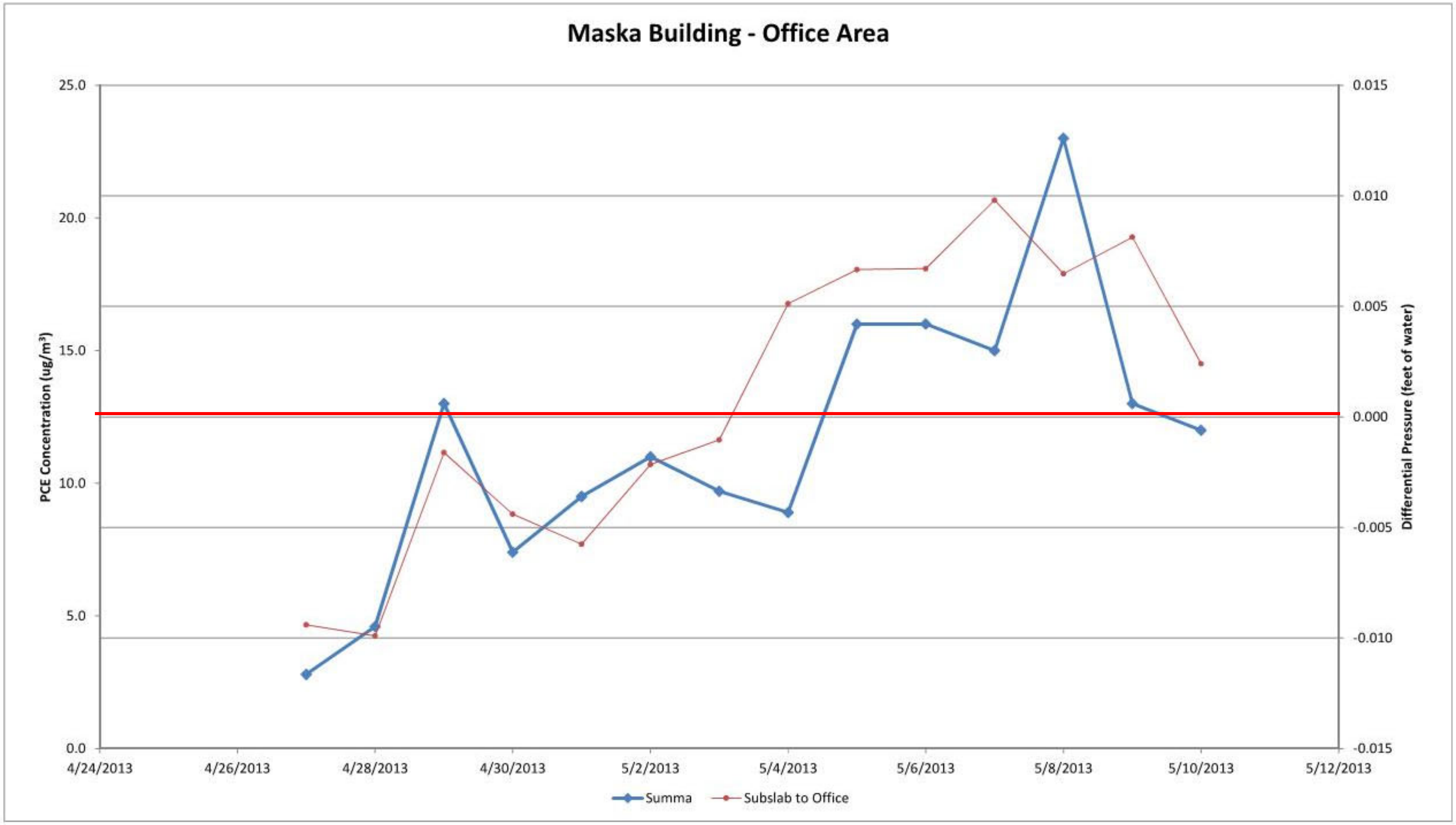
Maska Building



Differential Pressures Subslab to Outside & Subslab to Cresting Increase with Warmer Temperatures Inside


Maska Building - Cresting Area
PCE Concentration (ug/m³)
Differential Pressure (feet of water)
100
90
80
70
60
50
40
30
20
10
0
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
4/24/2013
4/26/2013
4/28/2013
4/30/2013
5/2/2013
5/4/2013
5/6/2013
5/8/2013
5/10/2013
5/12/2013
Summa
Subslab to Cresting Area



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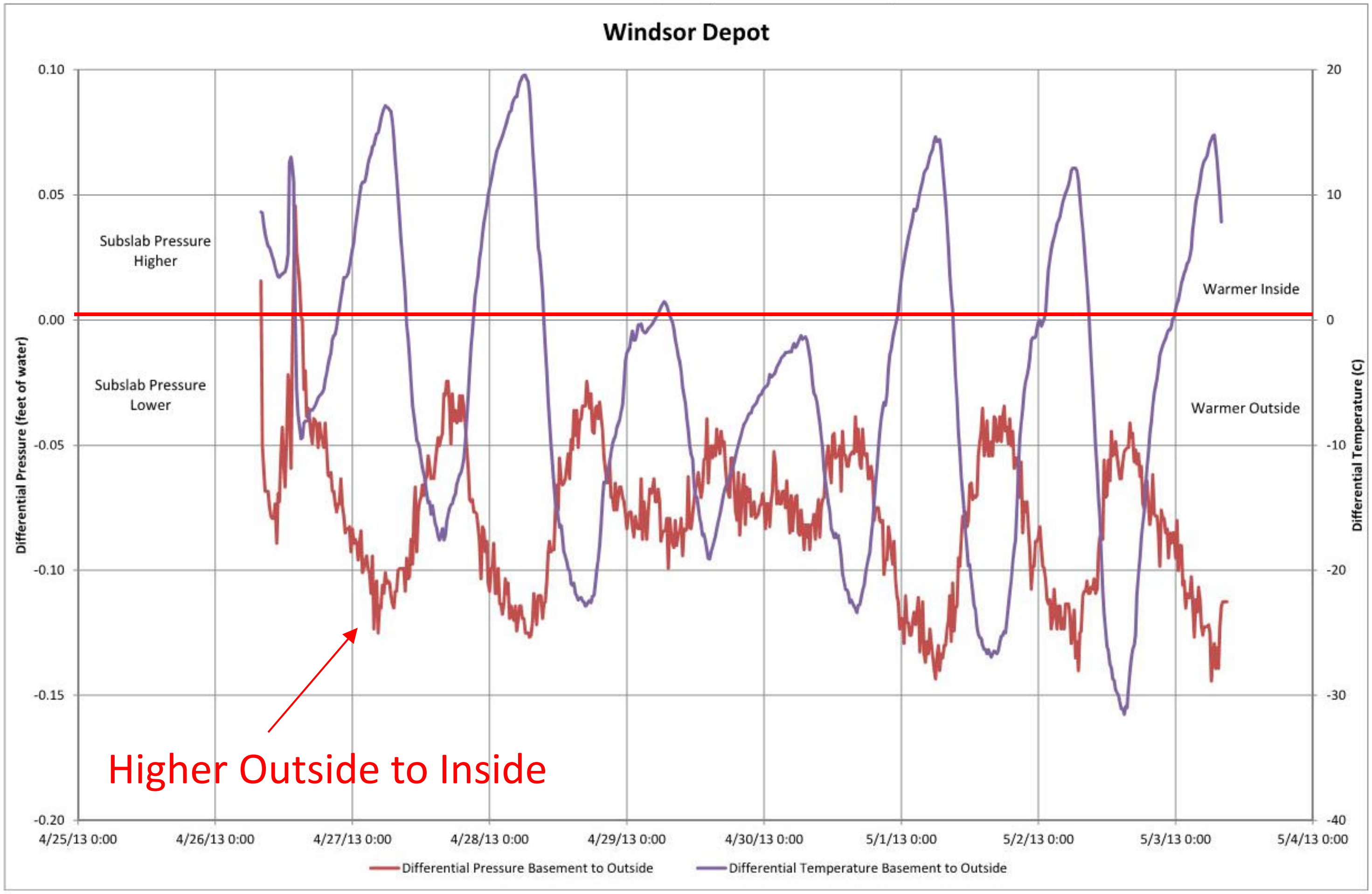
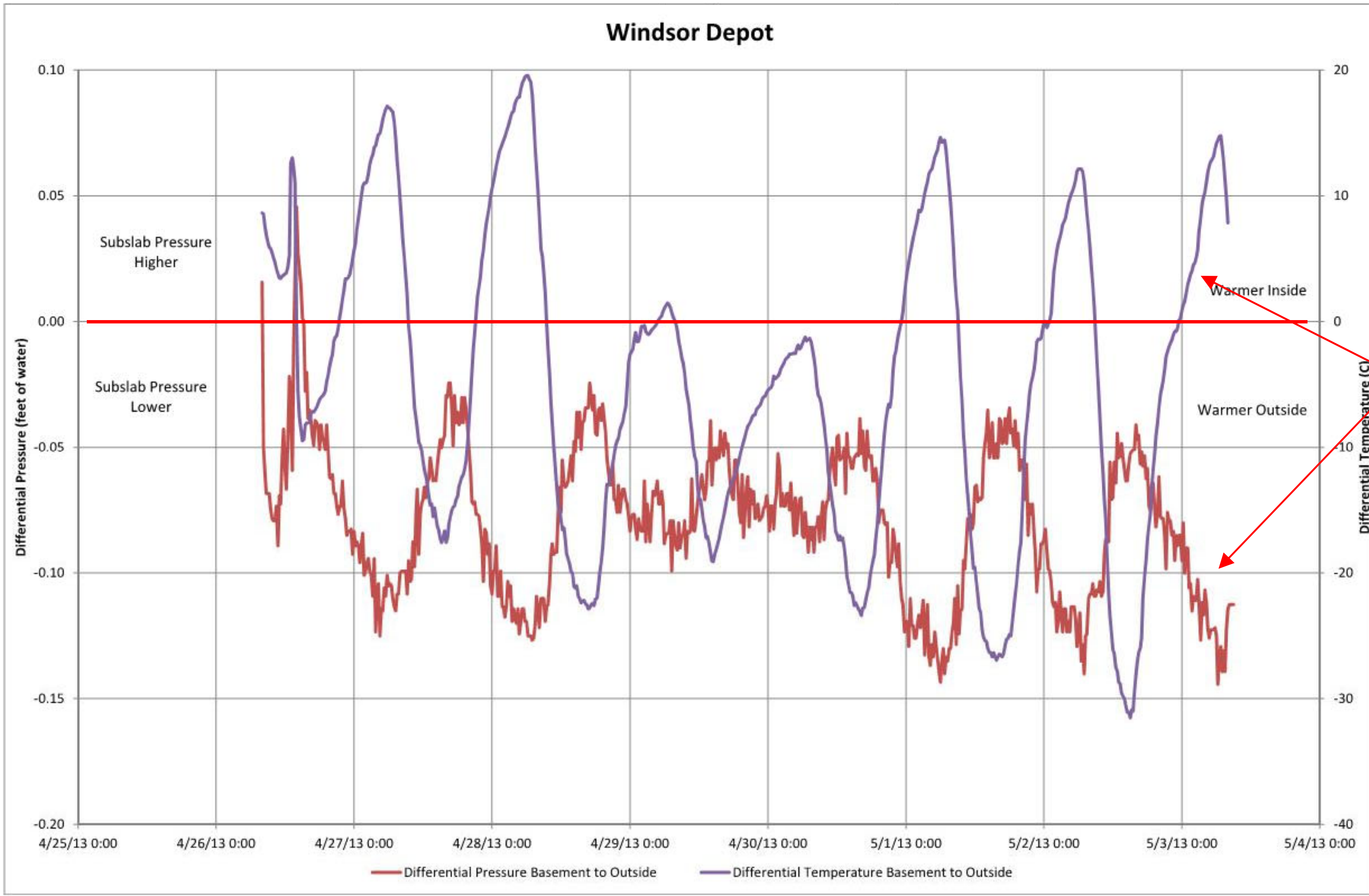
Windsor Depot

Former Railroad Depot Redeveloped as Restaurant

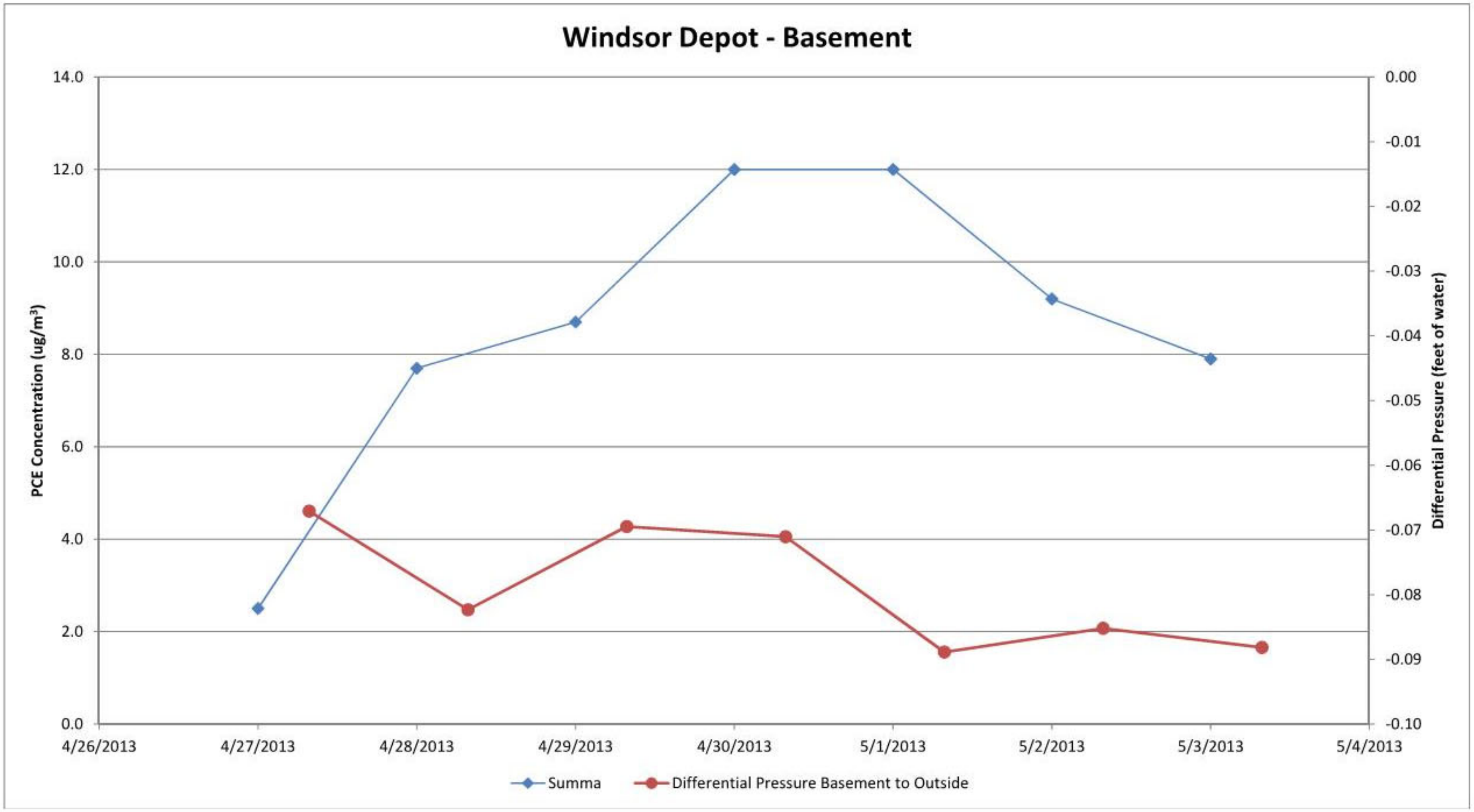
PCE Migrating Onto Site in Groundwater

- Basement and Crawlspace in Poor Condition
- Groundwater within 5’ of Basement
- HVAC Off for Study
- 2,888 sq. ft.
- Basement to 1st Floor “connected”


Windsor Depot
Subslab Pressure Higher
Subslab Pressure Lower
Warmer Inside
Warmer Outside
Higher Outside to Inside
Differential Pressure (feet of water)
Differential Temperature (C)
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
20
10
0
-10
-20
-30
-40
4/25/13 0:00
4/26/13 0:00
4/27/13 0:00
4/28/13 0:00
4/29/13 0:00
4/30/13 0:00
5/1/13 0:00
5/2/13 0:00
5/3/13 0:00
5/4/13 0:00
Differential Pressure Basement to Outside
Differential Temperature Basement to Outside



Diff Pressures Basement to Outside Decrease When Building is Warmer than Outside


Windsor Depot - Basement
PCE Concentration (ug/m³)
Differential Pressure (feet of water)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.10
4/26/2013
4/27/2013
4/28/2013
4/29/2013
4/30/2013
5/1/2013
5/2/2013
5/3/2013
5/4/2013
Summa
Differential Pressure Basement to Outside

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Conclusions

- Differential pressures and temperatures between the subslab, building and outside fluctuated diurnally.
- The diurnal differential pressure changes appear to be directly related to the relative temperature difference between the outside air and inside air.
- At the Maska Site, increased differential pressures resulted in increased indoor PCE concentrations.
- At the Windsor Depot the same relationship was seen in the Basement portion of the building. However, the exact opposite was true for the 1st Floor. PCE concentrations decreased with increases in differential pressure.

Conclusions

- Utilization of differential pressure and temperature monitoring dataloggers in the subslab, indoor and outside should be included in any evaluation of vapor intrusion potential.

- These data assist in determining vapor intrusion potential by considering impacts of atmospheric conditions, building HVAC operations and building occupation frequency.

Aside

- A SubSlab Depressurization System was installed at the Maska Building “Cresting Area” only. Indoor Air PCE Concentrations in both the “Cresting Area” AND the “Office Area” are now Non-Detect.

Questions?