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Case Study: Large Vapor Intrusion Site

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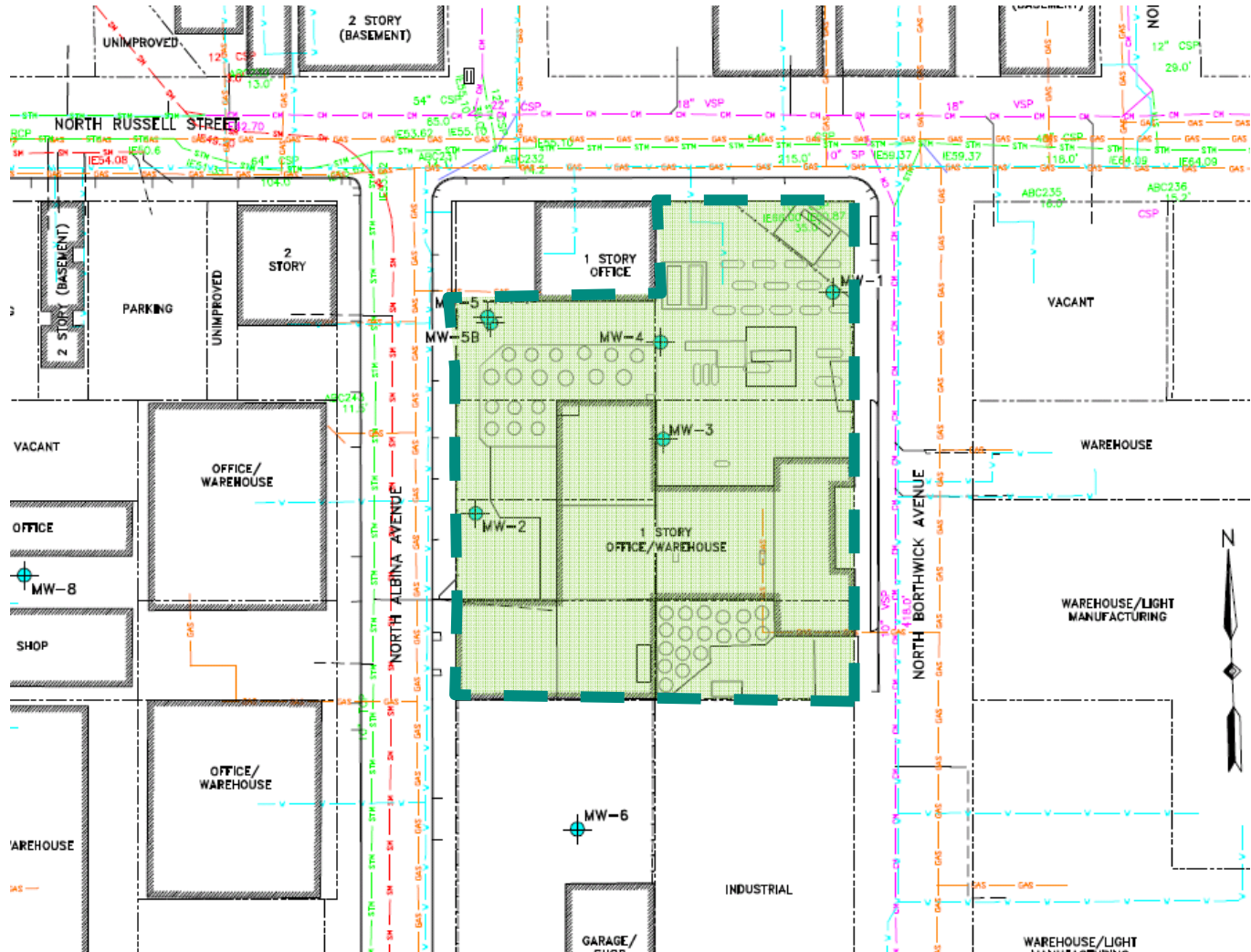
VI Investigation- Bulk Solvent Storage Facility

- Located in an industrial/commercial area
- Stored both chlorinated and petroleum solvents
- Primary releases from UST with spills and leaks in AST areas
- Vadose zone is approximately 45-50 ft thick 15 ft of fine-grained sandy-silt overlying a fine-medium sand
- GW plume dives below water table approx. 650 ft downgradient of source

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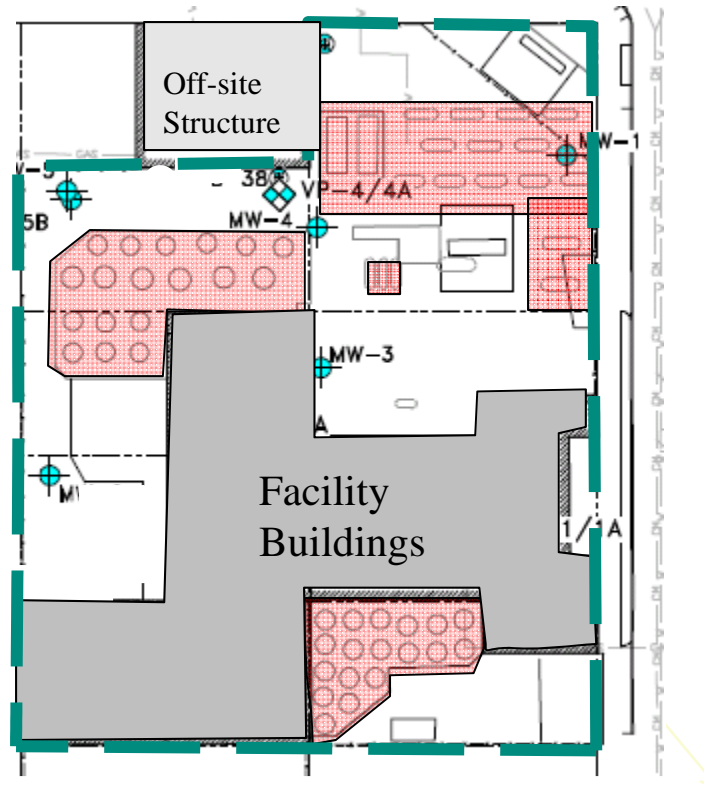


Facility Setting

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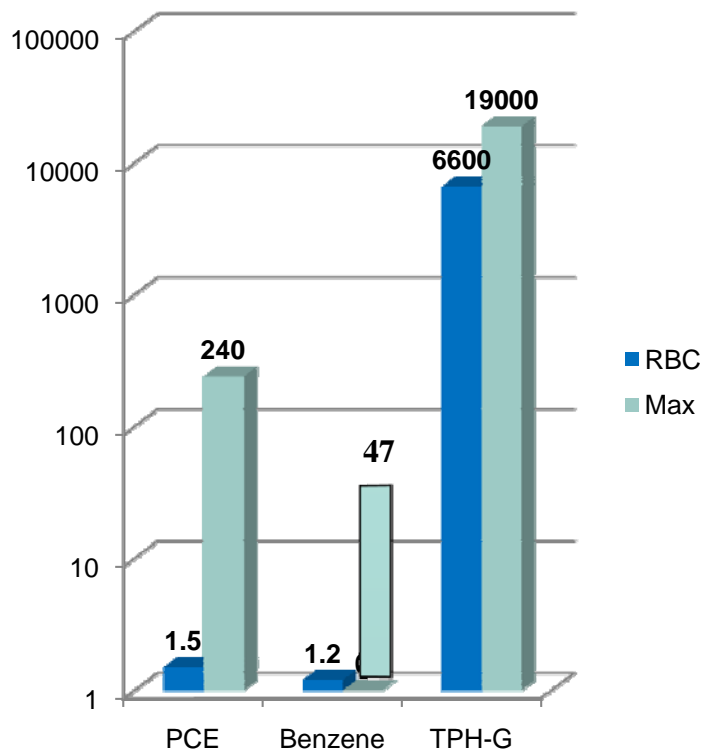


Storage Areas and Buildings

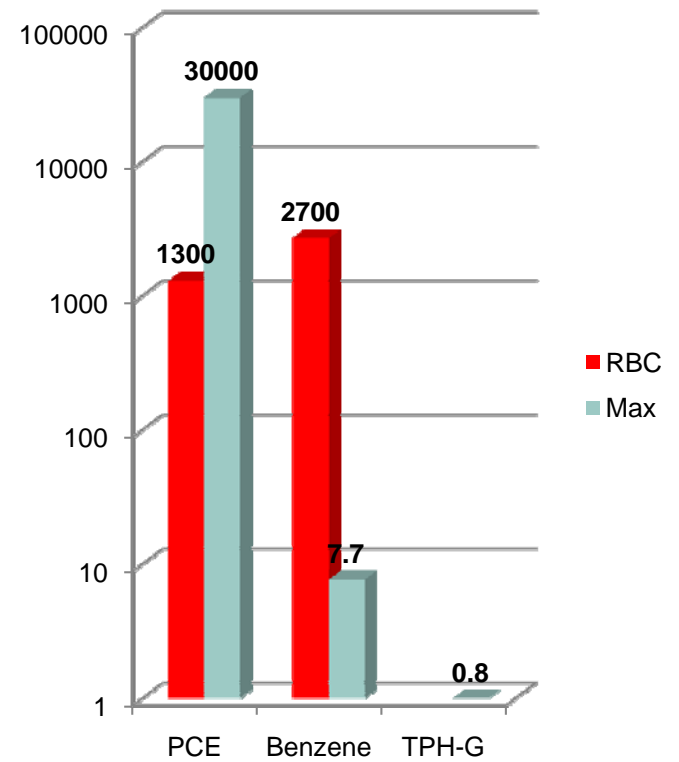


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Site Maximums vs. RBCs



Soil (mg/kg)

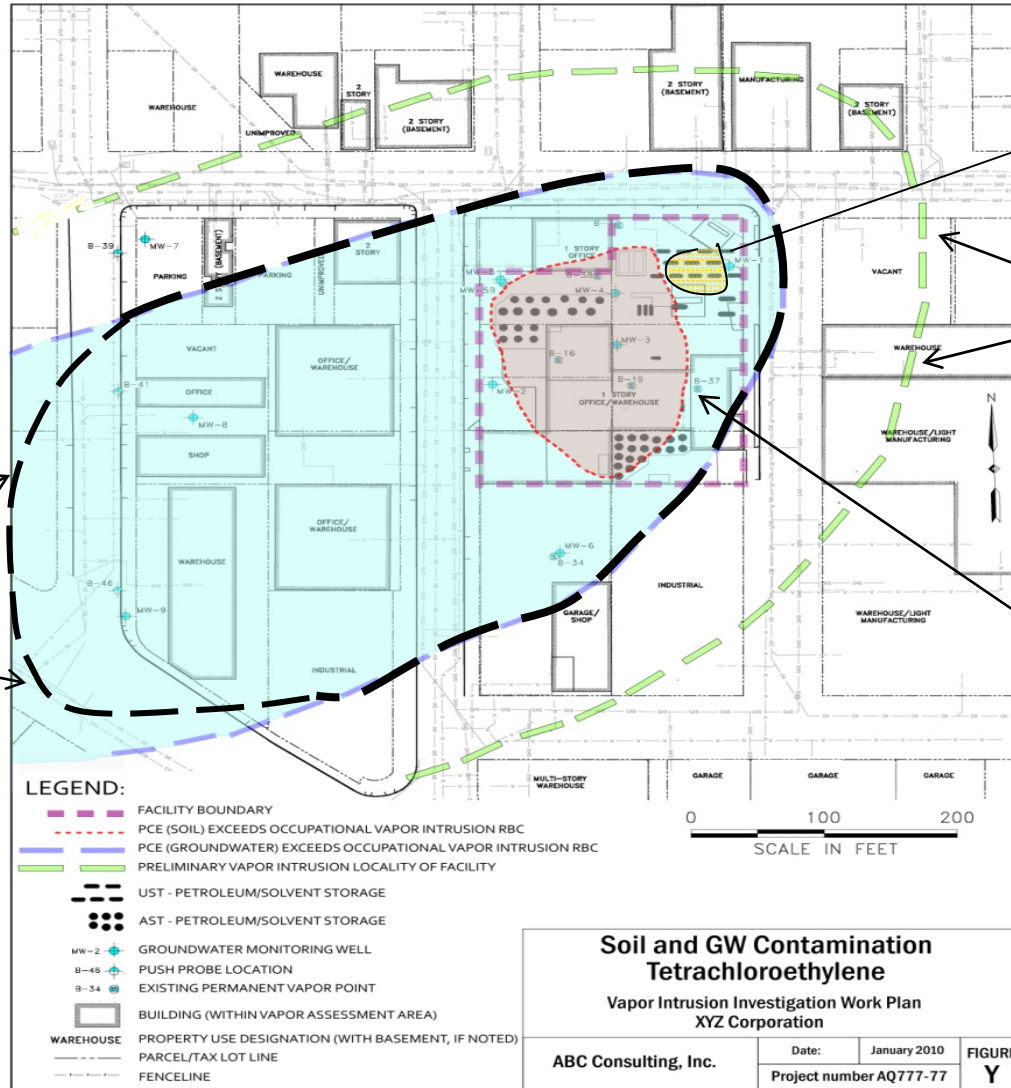


GW (ug/l)

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Soil exceeding gasoline, BTEX RBCs

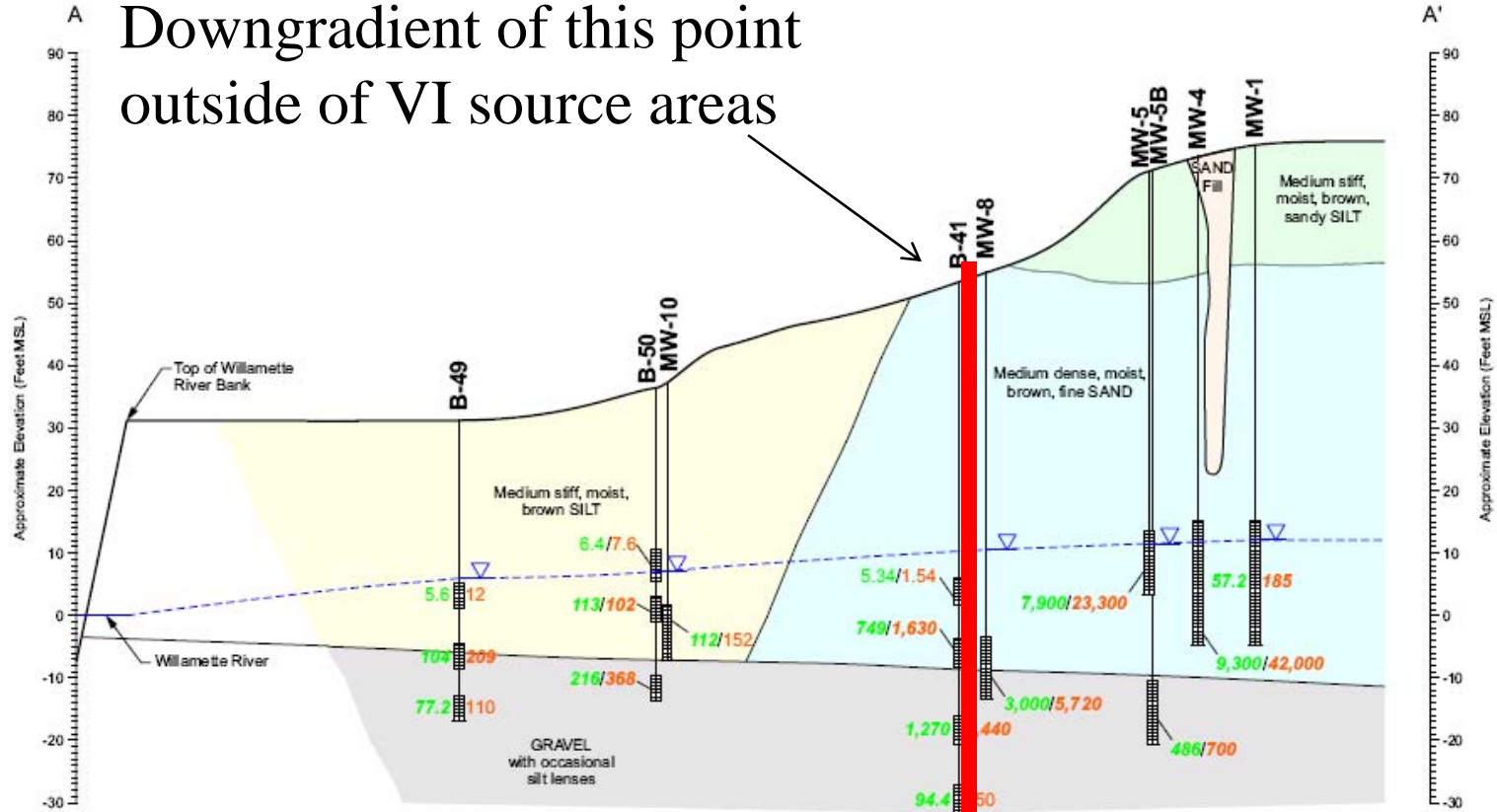
Preliminary LOF

Soil exceeding PCE RBCs

Extent of Plume at water table above RBCs

Plume Map

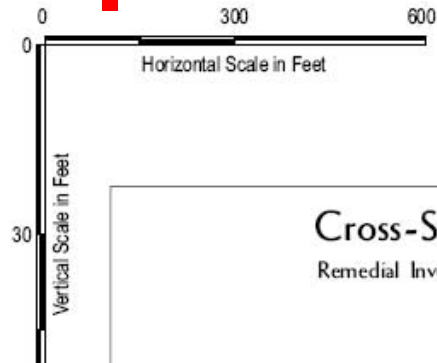
Downgradient of this point outside of VI source areas



Legend:

- MW-1 Monitoring Well/Probe Location
- Monitoring Well/Probe Location
- Typical Groundwater Level
- Screen Interval
- 57.2 185 Trichloroethene (TCE)/Tetrachloroethene (PCE) Concentration in $\mu\text{g/L}$
(***Bold Italic*** = Exceeds RBC - Urban Residential)

- Fill
- Sand
- Sand/Silt
- Silt
- Gravel





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1st Question – Are Volatile Contaminants Present at Sufficient Concentration for Vapor Intrusion?

	Site #1	Criteria Met
Contaminants Released	PCE	Yes
	TPH-G/Benzene	Yes
Concentrations (Maximums)	PCE: Soil – 240 ppm (0-43 ft); Shallow GW- 40,000 ug/l	Yes
	TPH-G: 19,000 ppm @ 25-45 ft;	yes
	Benzene: 47 ppm @ 38' bgs; 7.7 ug/l	No
Receptors (Current)	Commercial: < 100 ft,	Yes



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Initial Screening

RBDM Soil and Groundwater RBCs
exceeded at Site #1

Contaminant source in vadose zone and
shallow groundwater (no overlying lens of
clean water)

Receptors are located above source area

Proceed to Soil Gas/Subslab Sampling



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Question #2 – Are Soil Gas Levels Sufficiently High to Pose a VI Risk?

- Collect worst-case samples – directly above or within source areas
- Temporary or Permanent Points
- Ideally, MRLs 1/10th Soil Gas RBCs
 - In consideration of seasonal fluctuations
- Evaluate all VI COIs



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Initial Soil Vapor Sampling

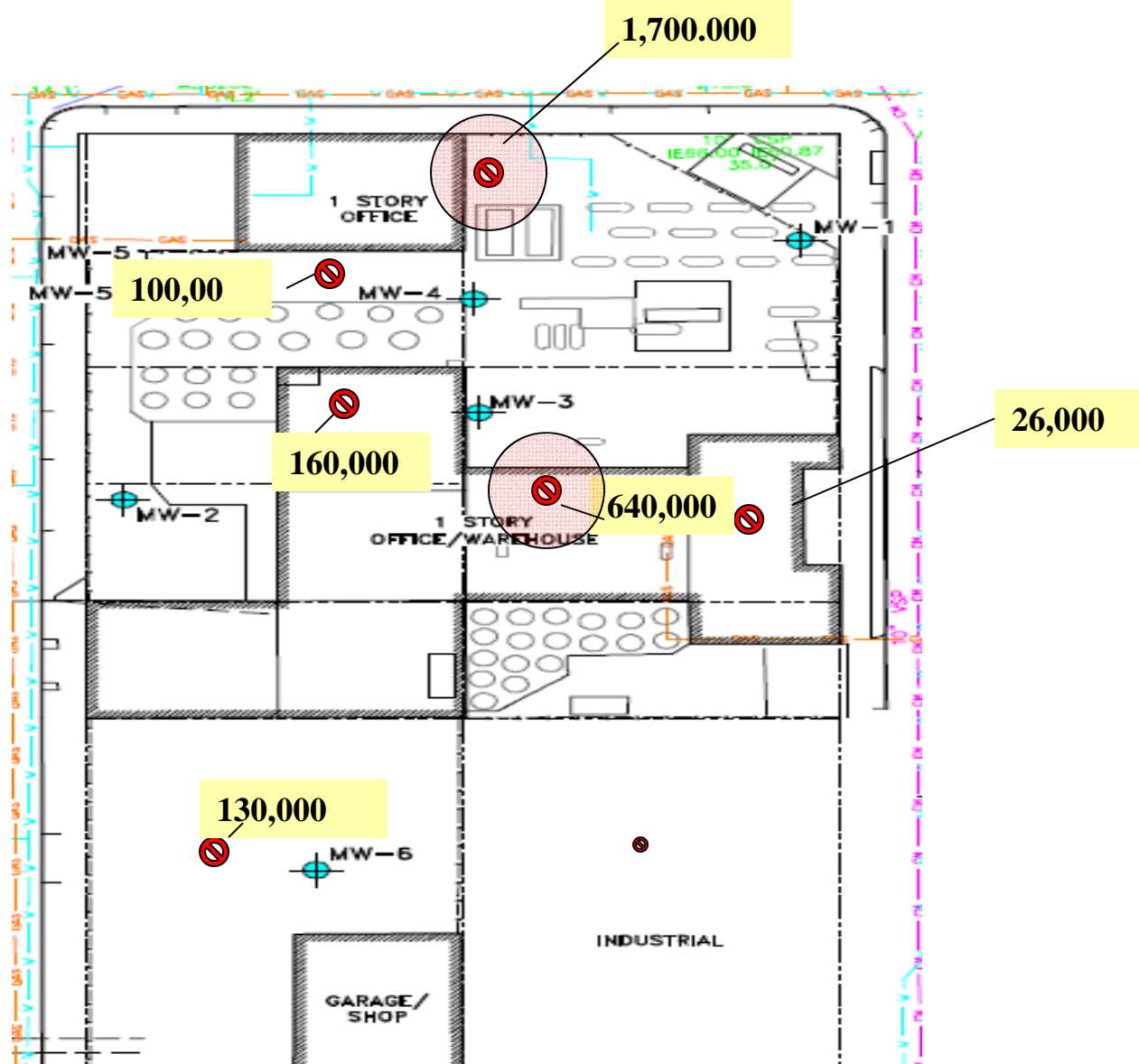
- Collect a limited set of soil gas outside of and within the footprint of on-site building
- Permanent vapor sampling points chosen based on magnitude of soil and groundwater impacts
- Vapor monitoring points screened from 1-1.5' bgs (not recommended)
- Chose method TO-15, but could have argued for 8260B

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PCE Occ. Soil Gas
RBC -1,900 ug/m³



Soil Vapor Sampling - PCE (ug/m³)



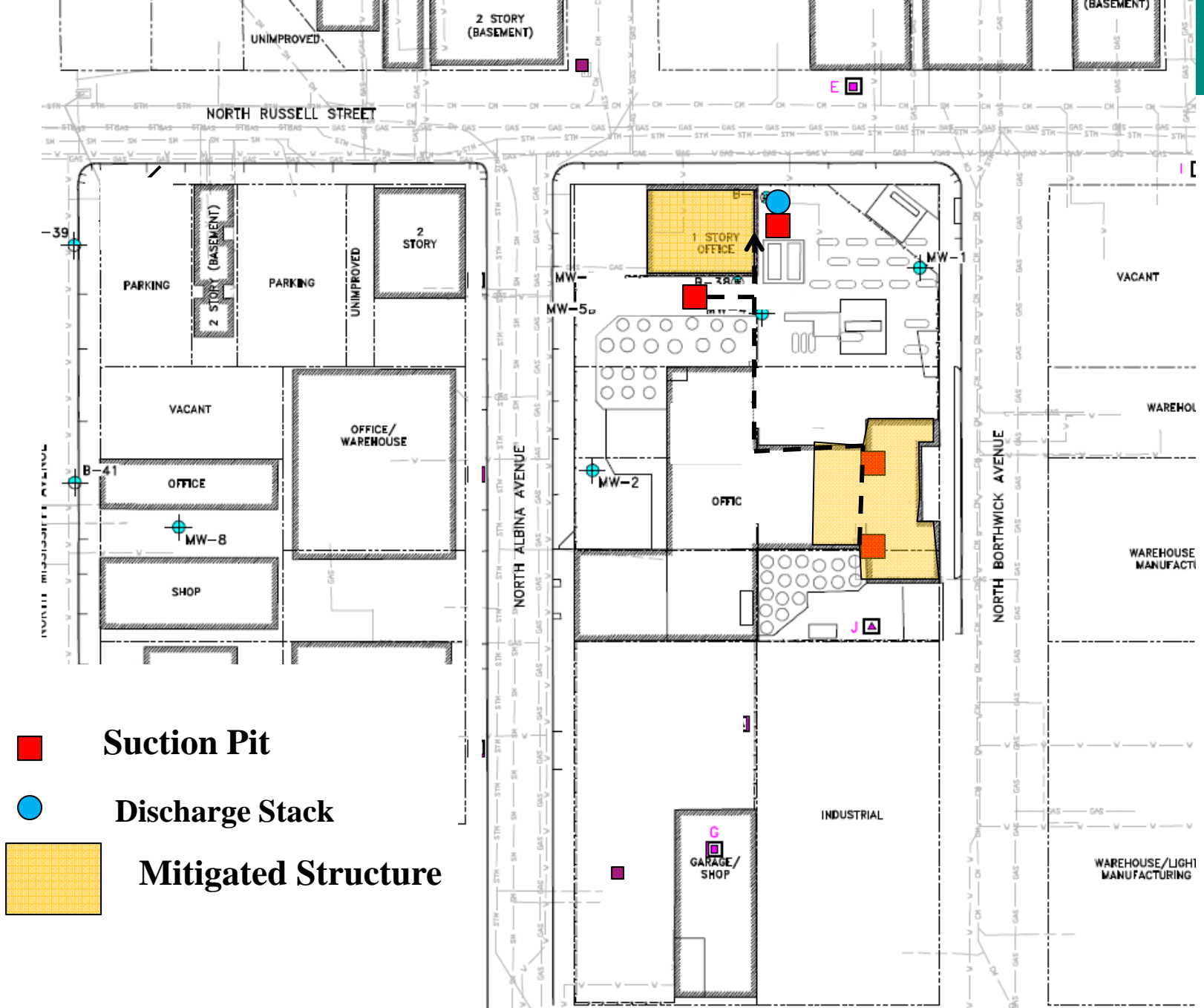
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First Phase – Results and Follow-up

- Benzene was non-detect (biodegradation suspected - impacts are >25 ft bgs, GW data indicates aerobic conditions – **dropped as VI COI**)
- PCE exceeded hot spot levels beneath and adjacent to two buildings – **VI Mitigation Proposed**
- PCE Soil Gas RBCs exceeded by a large margin at all points – **Install Additional Vapor Monitoring Points**



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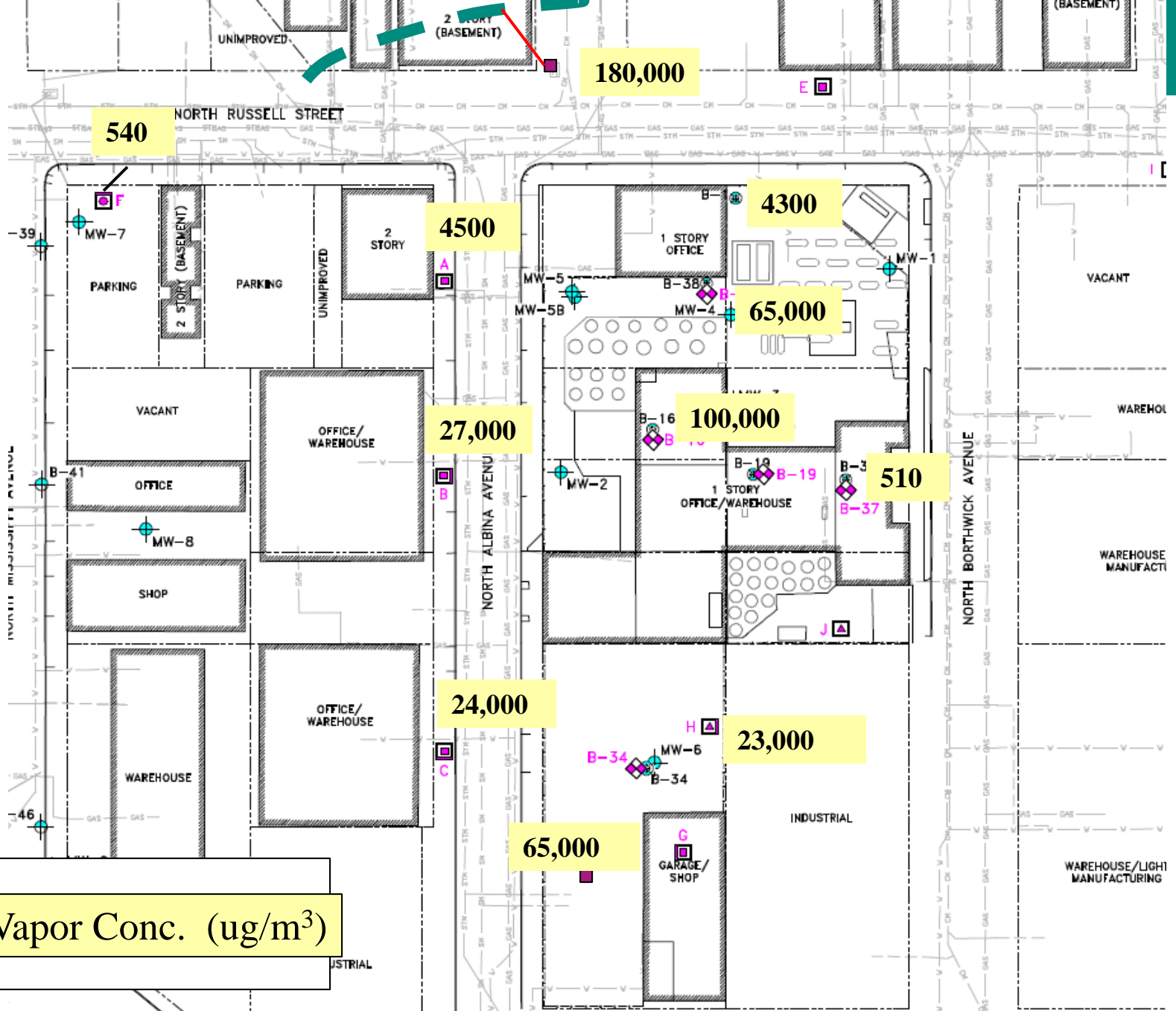
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Phase 2 – Sampling Approach and Rationale

- Add permanent soil vapor monitoring points – to track concentration trends, influence and effectiveness of remedial systems
- Locate adjacent to existing buildings – to assess vulnerability but avoid access issues
- Screened at or below 5' bgs – conform with soil gas sampling protocols
- Large-scale spacing to quickly and efficiently delineate extent of vapor impacts



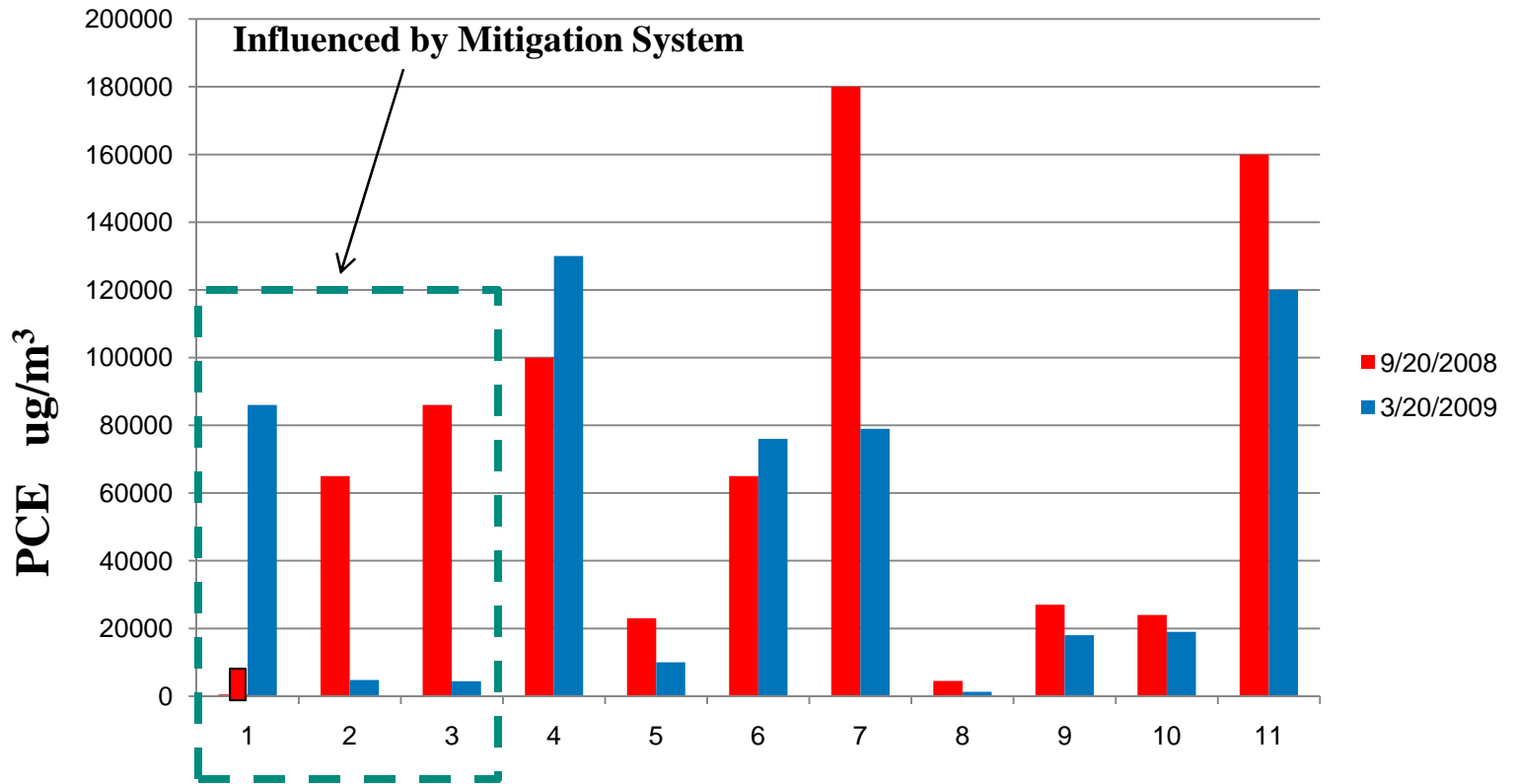
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Seasonal Variability in Soil Vapor Concentrations



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Phase 2 Sample Results and Follow-up

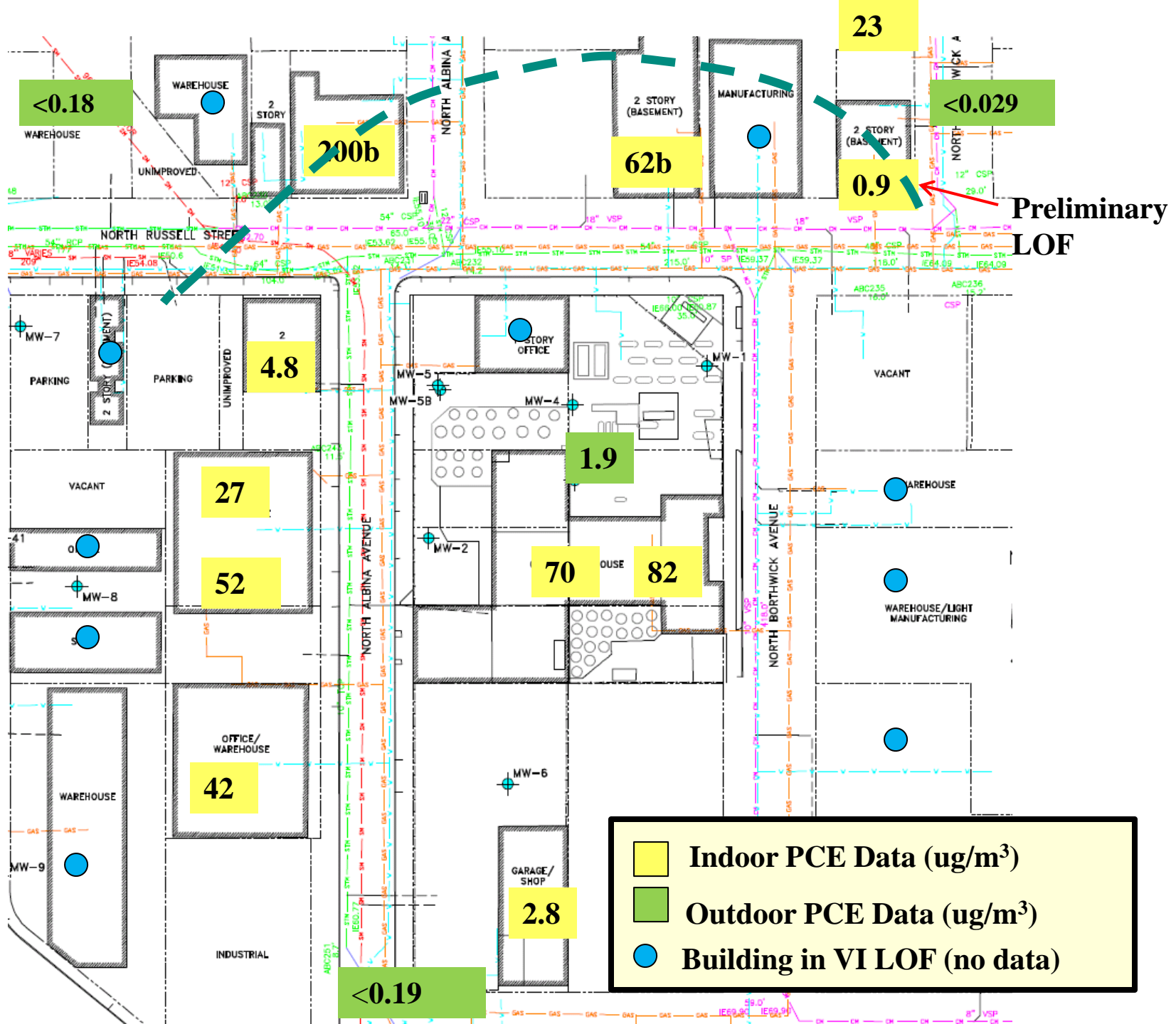
- PCE vapor plume still not fully delineated – **additional investigation necessary**
- Concentrations not easily contoured – “patchy fog”
- Expanded vapor plume intersects multiple buildings (exposure units) – **Indoor Sampling Proposed, Larger scale IRAM necessary**
- Seasonal Variability approximately 3x in most points with a maximum of 10x



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Indoor Sampling

- Targeted most vulnerable buildings (allowing access)
- Basements sampled when present
- Required TO-15 SIM to achieve necessary MRLs
- Eight hour samples collected at breathing height and typical operating conditions



**Preliminary
LOF**

	Indoor PCE Data (ug/m³)
	Outdoor PCE Data (ug/m³)
	Building in VI LOF (no data)

<0.18

200b

62b

23

0.9

<0.029

4.8

27

52

42

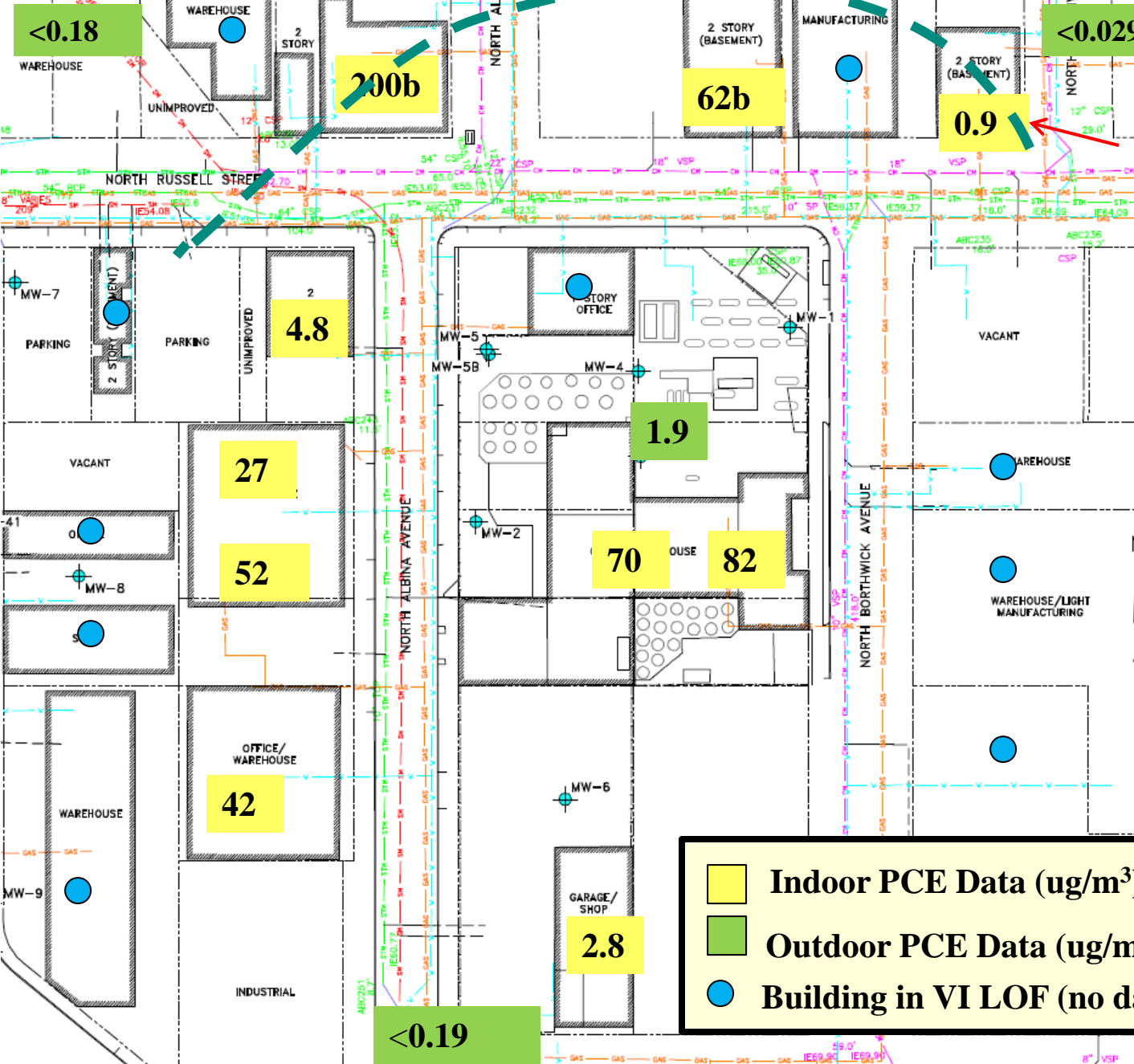
1.9

70

82

2.8

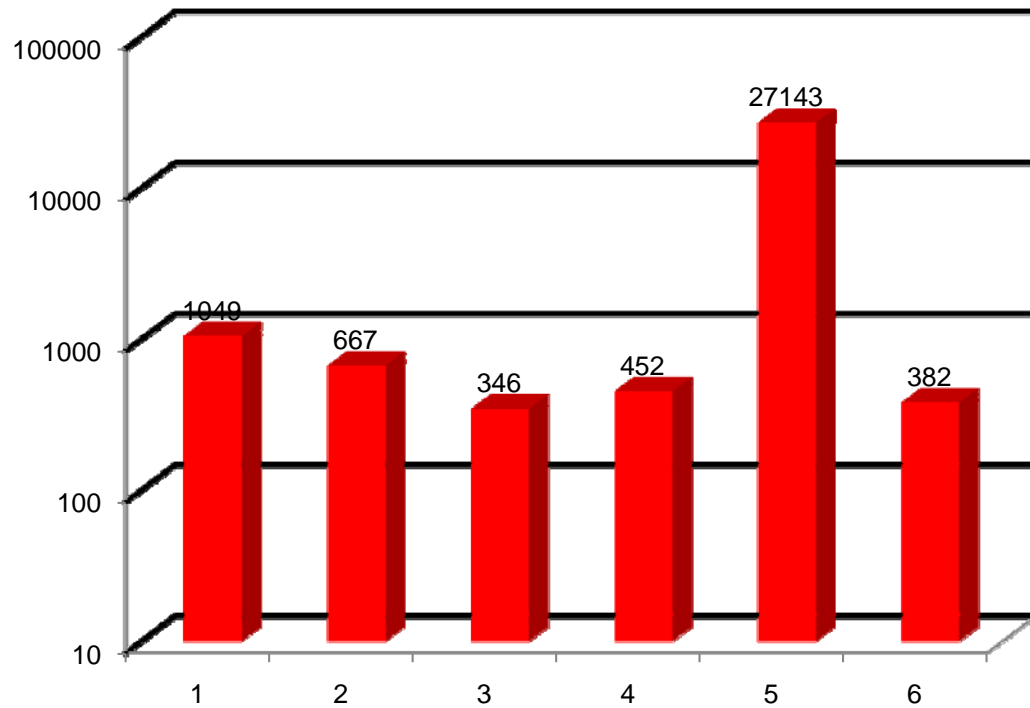
<0.19



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Attenuation Factors for Six Buildings



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Indoor/Outdoor Sampling Results

- Data set limited by access/desire
- High concentrations observed in basements (>hot spot) lower at ground level (0.06-0.4x)
- Attenuation factors relatively consistent
 - Low values may be due to vapor well locations
- Outdoor ambient levels were negligible
 - Exception: center of plume –suggesting outdoor volatilization may have measurable impact
- Demonstrates need for IRAM and provides baseline data to evaluate effectiveness



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Indoor Sampling Results Continued

- Smaller enclosed spaces within buildings are more vulnerable
- Vapor LOF >100 ft potentially due to utilities, or due to the large and relatively deep source of VOCs
- Indoor air data from buildings can be misleading and are not the best indicator of the vapor plume LOF
 - Variability in building design and construction
 - Subsurface data should be the primary source for delineating



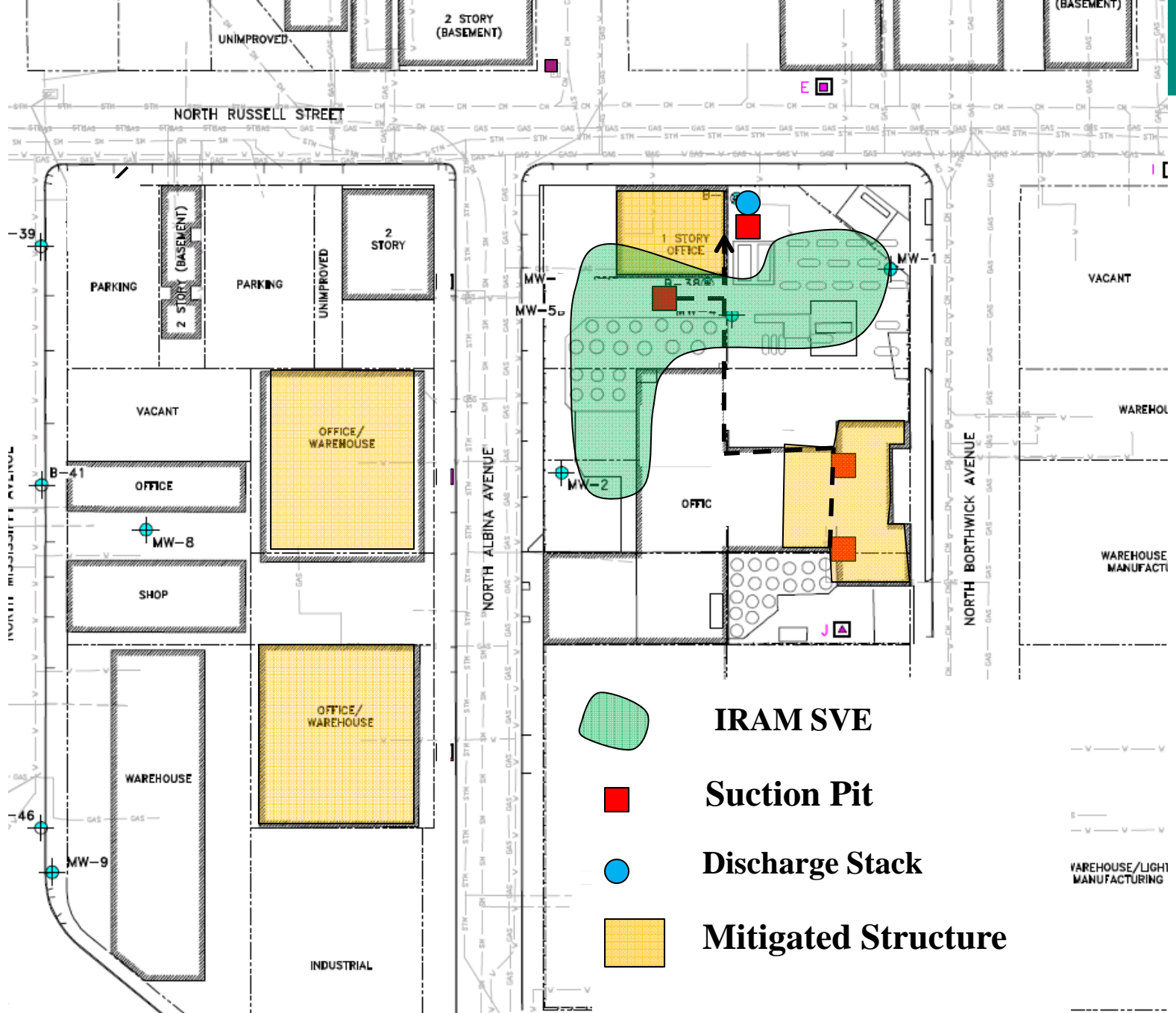
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Mitigation Measures and IRAM Design

- Operation of suction pits reduced levels in subsurface, but did not achieve compliance indoors
- Off-site buildings had HVAC systems adjusted and floor seams sealed – improvement seen
- SVE system installed targeting two depths 0-15 ft bgs and 15-50 ft bgs
- Sustained improvements in indoor air quality (in building 80 ft from source) observed within 2 months of operation



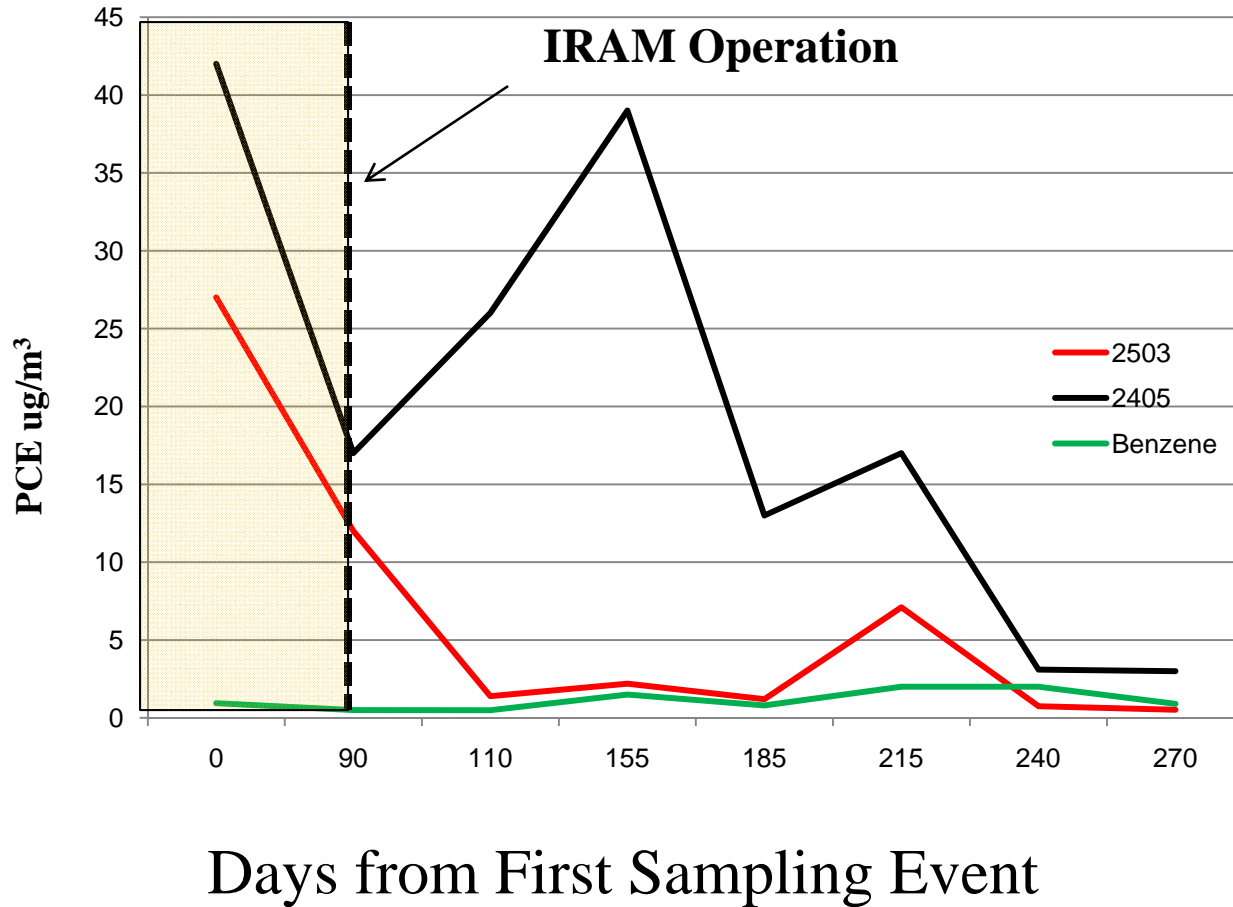
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Indoor Air Quality Trends





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Lessons

- Recognizing scale of impacts
- Need to more quickly and efficiently delineate vapor plumes
- 100 ft vapor LOF setback not always conservative
- Be prepared for risk communication



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Next Steps

- Complete vapor plume delineation
- Continue monitoring indoor air and vapor monitoring wells
- Develop and implement a more comprehensive remedial design
- Address groundwater plume