

Continuous Indoor Air Sampling

to Understand Variable Concentrations of Trichloroethene
in a Complex Industrial Facility

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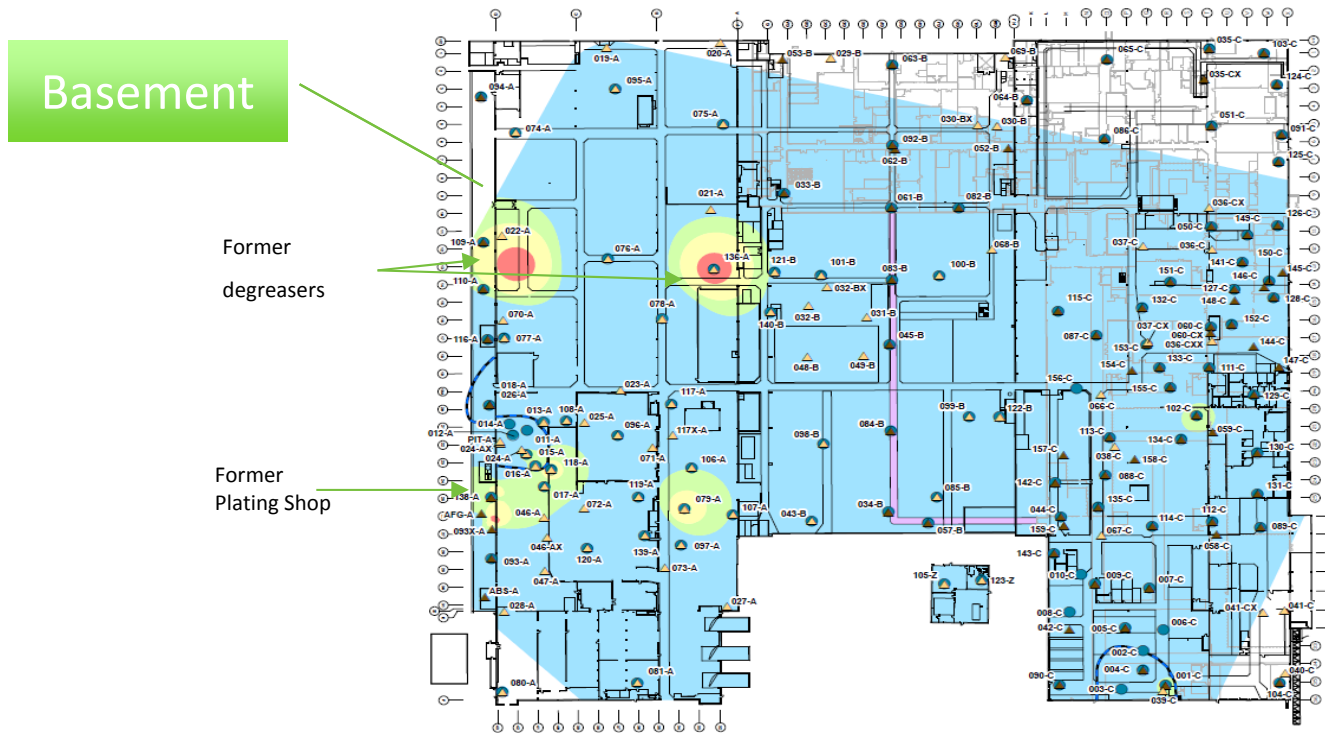
Eleventh International Conference on Remediation of Chlorinated and Recalcitrant Compounds

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Presentation Objective and Outline

- Objective: demonstrate new tool available to monitor vapor intrusion
 - Compare to existing sampling approaches
 - Better understand fluctuating nature of indoor air concentrations
- Outline:
 - Building layout; contaminant sources
 - Basement problems
 - Basement solutions, including:
 - Continuous indoor air sampling
 - Subsequent steps

Building Sources and Sampling Locations



Contaminant Sources

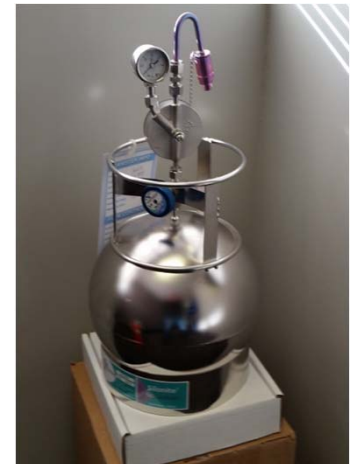
- Trichloroethene (TCE) present under the main floor is likely from:
 - Leakage from former degreasers
 - Historical operations from former plating shop (southwest area)
- Once present in the subsurface, TCE likely migrated through soil to groundwater beneath the building to the basement
 - TCE volatilizes from water present in basement sumps and drains into indoor air in the basement

Traditional Sampling Approaches

- Traditional sub-slab and vapor pin installation



- Summa canisters to sample:
 - Sub-slab vapor
 - Indoor air (breathing zone) – 8 hours



Problem: Periodic TCE Indoor Air Exceedences in Building A Basement between 2013 - 2016

Round	Location 093-A	Location 093-X	Location 138-A
Round 15 Aug 2013	13 *	---	2.9
Round 16 Feb 2014	5.9	8.4	1.6
Round 17 Sept 2014	9.2 *	---	5.5
resample October 2, 2014	12.2 *	---	---
093-A-R17A August 21, 2014	10.6 *	---	---
093-A-R17B August 27, 2014	9.9 *	---	---
Round 18 Feb 2015	1.5	8.3	1.6
Round 19 Aug 2015	3.3	---	0.87 J
Round 20 Feb 2016	6.4	---	12 *
resample March 11, 2016	---	---	2.4
Round 21 Aug 2016	6.0	---	2.7
Round 22 Feb 2017	1.8		11 *
All reported concentrations in units of $\mu\text{g}/\text{m}^3$		<ul style="list-style-type: none"> Exceeds TCE Indoor Air VISL $8.8 \mu\text{g}/\text{m}^3$ where VISL = Vapor Intrusion Screening Level 	

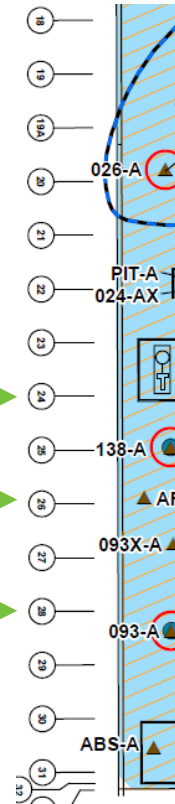
Basement Indoor Air Summa Locations 093-A and 138-A

Exceedences
near columns 26
and 28

Column 24

Column 26

Column 28



138-A

093-X

093-A

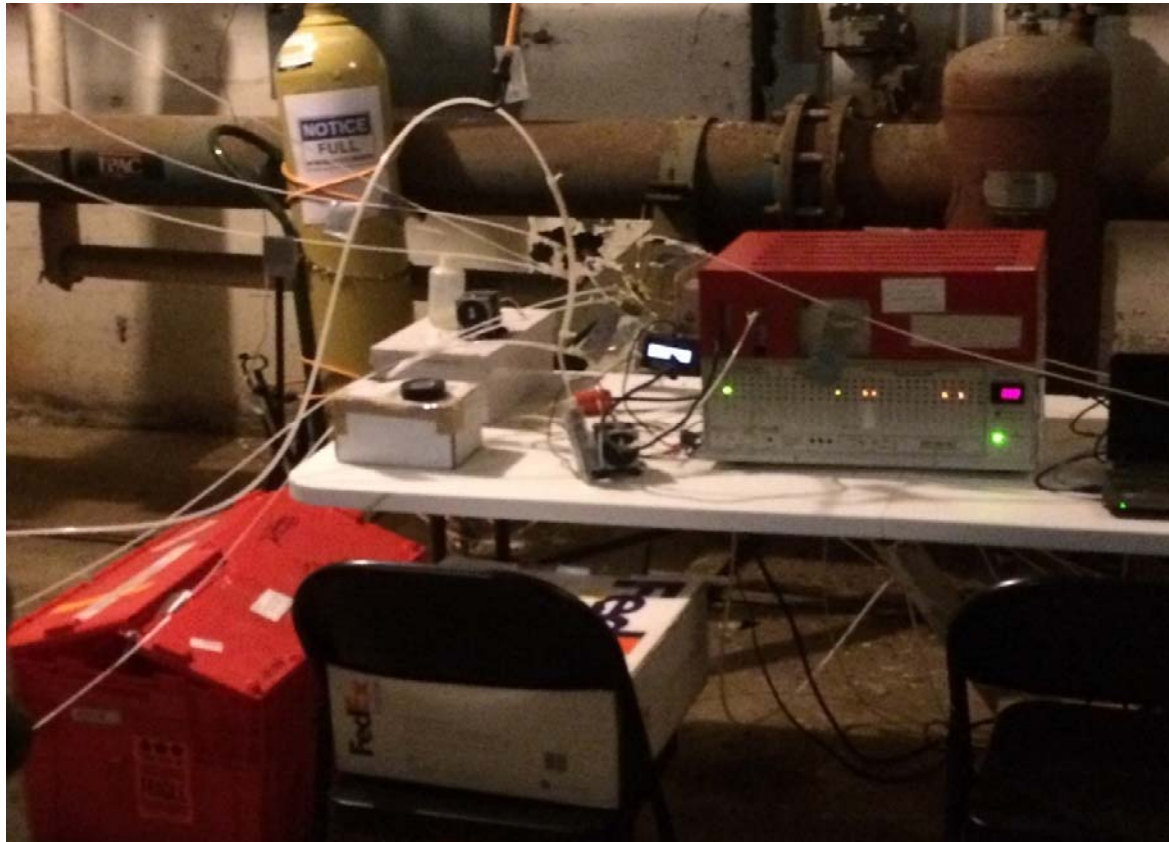
Additional Investigations in Basement

- Surveyed possible preferential pathway floor features in the basement using a Frog-4000™ field gas chromatograph (March 2016)
 - Identified sumps and floor drains as potential sources of TCE vapor from water beneath basement floor
- Installed additional vapor monitoring points in the walls
- Collected standing water from the sumps, storm drains, lift station and from water ponded behind the freight elevator
- Implemented a **continuous air monitoring** system for two months (February 24 until April 21, 2017)



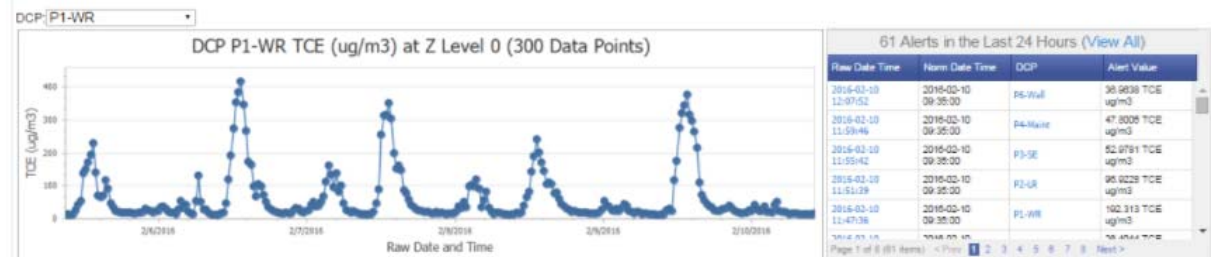
Continuous Air Sampling Set Up

Gas chromatography / electron capture detector (GC/ECD)

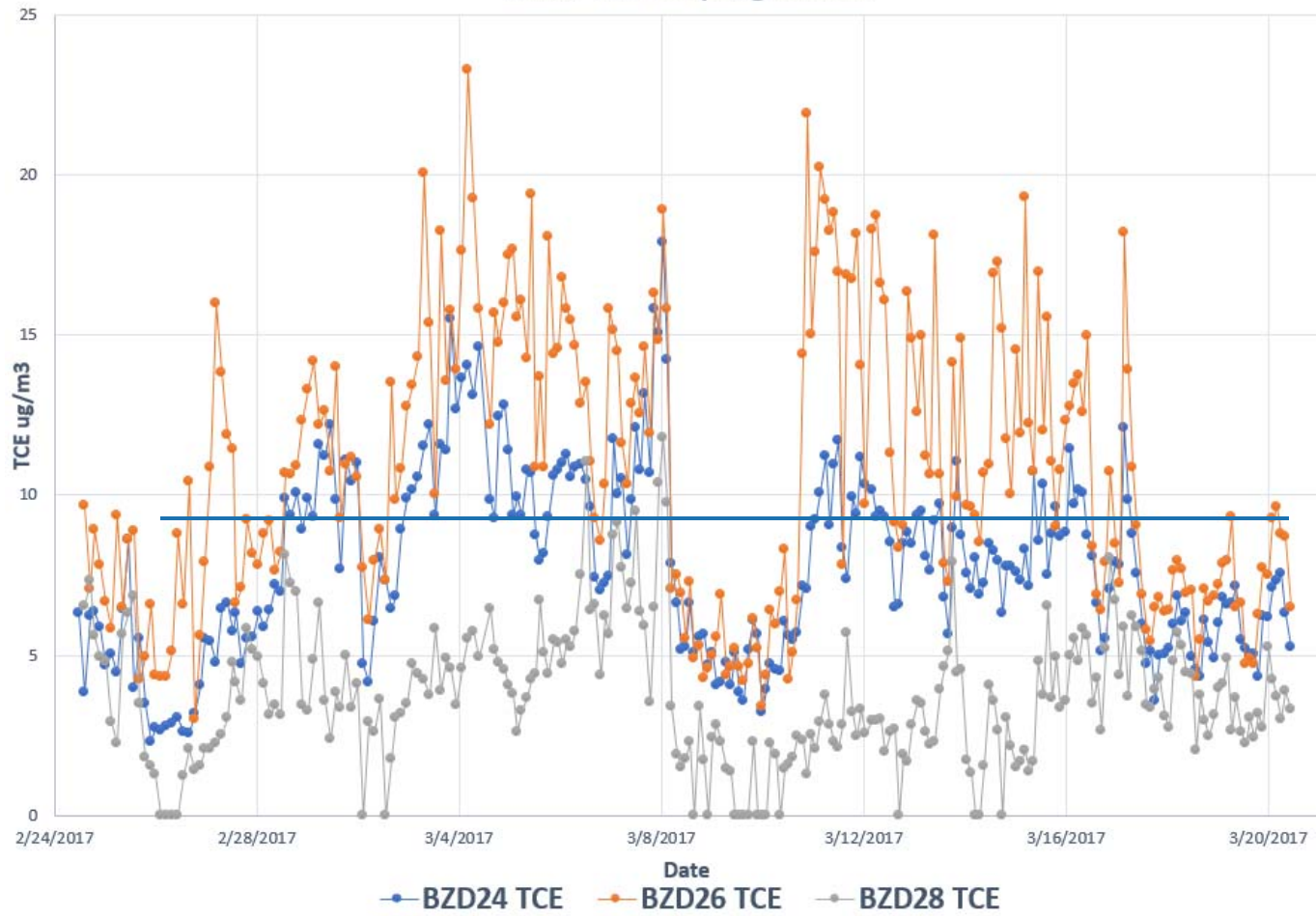


Continuous Air Sampling Set Up

- Gas chromatography / electron capture detector (GC/ECD) used to analyze for TCE using EPA Method TO-14
 - Provided by Dr. Blayne Hartman
 - Analyzed 15 sampling locations, plus calibration gas
 - Instrument reported ~9 readings at each location per day
 - ~10 minutes to analyze each location
 - Reporting limit 2.0 $\mu\text{g}/\text{m}^3$
- Groundswell Technologies earth monitoring software provided dashboard to review results daily



Initial TCE Sampling Results

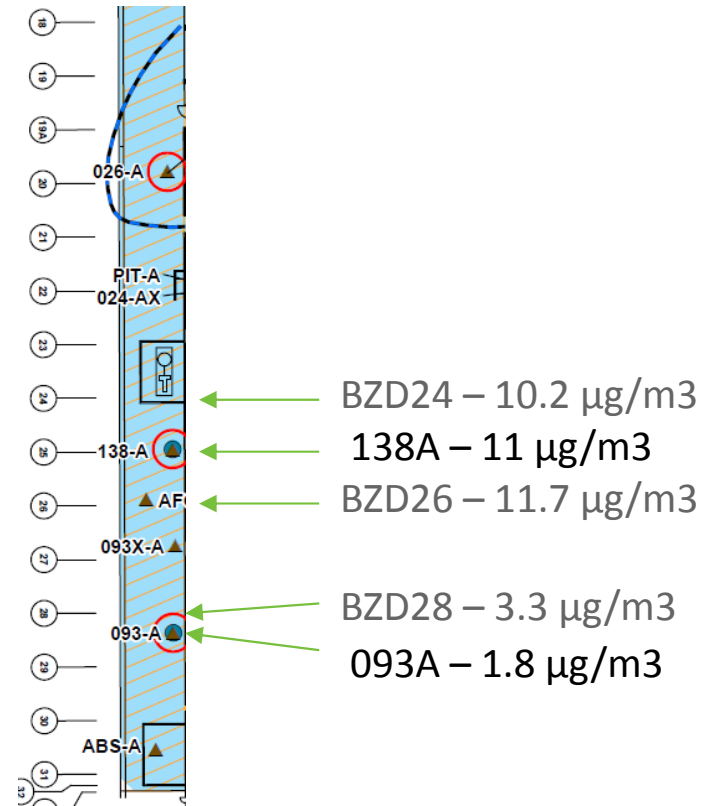


Initial Month TCE Results In Breathing Zone

	INITIAL MONTH TCE CONCENTRATIONS		
	Minimum Conc. $\mu\text{g}/\text{m}^3$	Maximum Conc. $\mu\text{g}/\text{m}^3$	Average Conc. $\mu\text{g}/\text{m}^3$
BACK	0.0	13.4 *	6.2
BZD-22	0.0	16.5 *	7.4
BZD-24	2.3	17.9 *	7.8
BZD-26	3.0	23.3 *	10.7 *
BZD-28	0.0	11.8 *	3.7
		* Exceeds TCE IA VISL $8.8 \mu\text{g}/\text{m}^3$	

Sampling Duration: February 24 – March 20, 2017

Indoor Air Summa Locations 093-A and 138-A vs Continuous Sampling



Initial Month Continuous Sampling Results

- 8-hour Summa canister sampling results were comparable to continuous sampling
- Results demonstrated that 8-hour Summa canister samples may not be effective for collecting representative samples when indoor air concentrations are close to screening level
- Actual TCE concentrations fluctuate continuously over time
 - Poor correlation with barometric pressure observed
 - Results possibly influenced by measurable rain events
- BZD-28 is closely located to Summa location 093-A
 - Average TCE concentration less than screening level of 8.8 µg/m³

Sampling Results Linked to TCE Sources

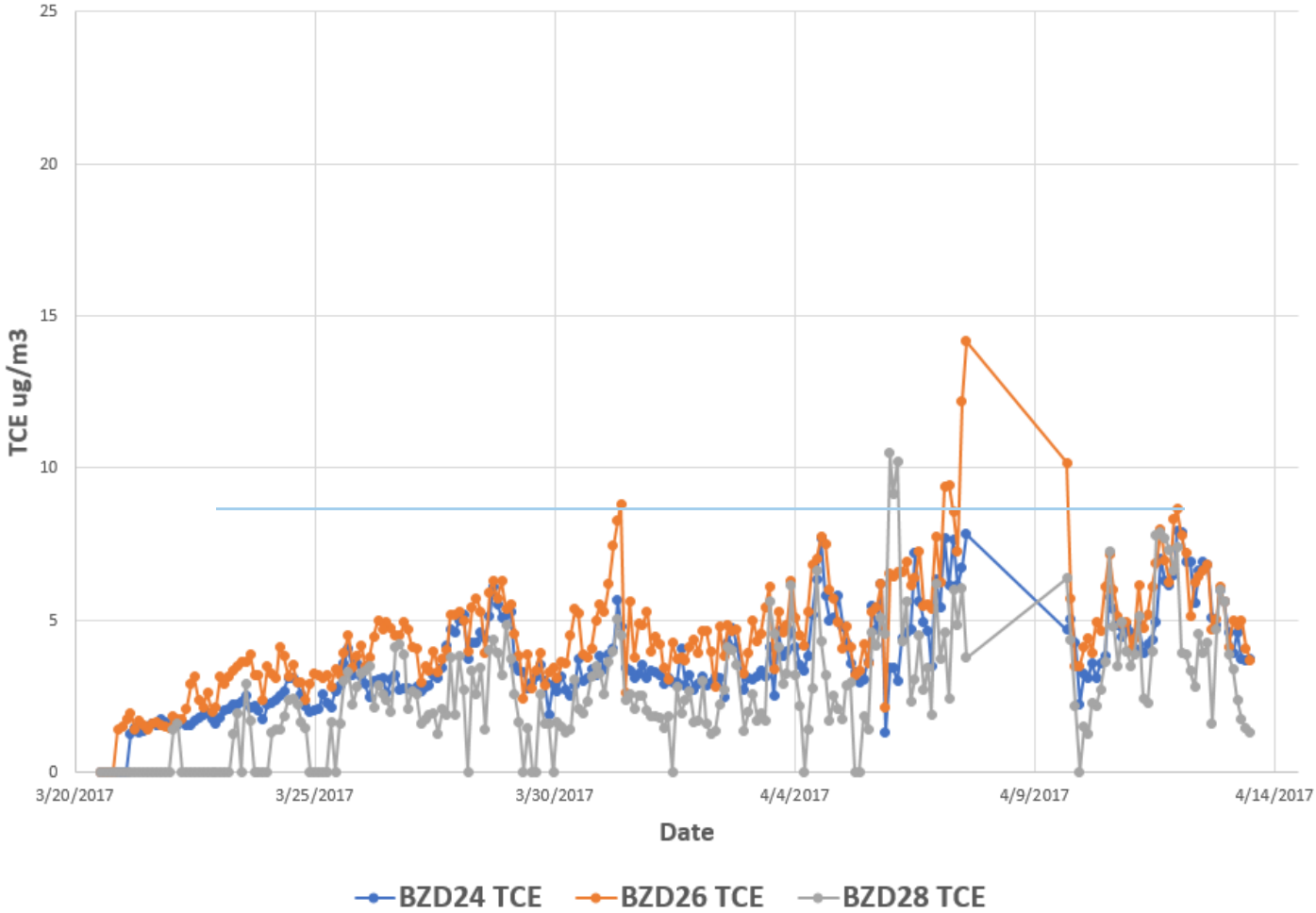
- Sampling results positively identified floor features with high levels of TCE vapor
 - Sump near BZD-26
 - HRS5 sump (approximately 3 feet deep below floor surface with approximately 2 inches of standing water)
 - TCE vapor concentrations between 400-600 $\mu\text{g}/\text{m}^3$ within sump
 - Sumps and floor drains near BZD-24
 - TCE vapor concentrations between 150-300 $\mu\text{g}/\text{m}^3$ within sump
 - TCE vapor concentrations between 10-50 $\mu\text{g}/\text{m}^3$ within drains

Solution: Covered Floor Features

- After a baseline of data was established, floor features were covered to measure impact to indoor air results
 - Breathing zone locations immediately decreased to concentrations near zero
 - Concentrations gradually began to increase over time



TCE Concentrations with Conduits Covered



TCE Results In Breathing Zone After Covering Floor Features

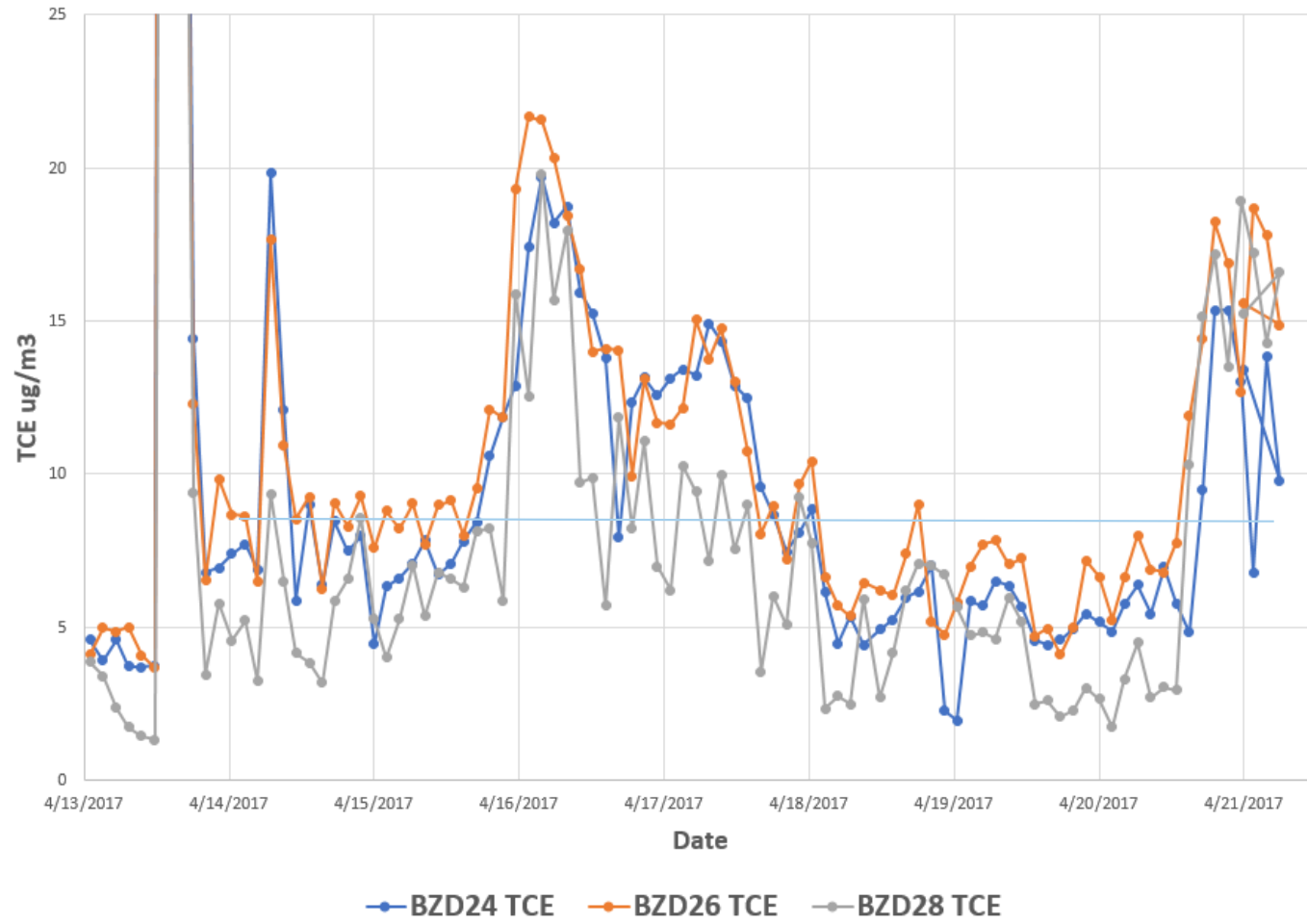
	TCE CONCENTRATIONS SUMPS COVERED		
	Minimum Conc. $\mu\text{g}/\text{m}^3$	Maximum Conc. $\mu\text{g}/\text{m}^3$	Average Conc. $\mu\text{g}/\text{m}^3$
BACK	0.0	14.4 *	3.4
BZD-22	0.0	7.8	2.1
BZD-24	0.0	7.9	3.6
BZD-26	0.0	14.2 *	4.5
BZD-28	0.0	10.5 *	2.5
		* Exceeds TCE IA VISL 8.8 $\mu\text{g}/\text{m}^3$	

Sampling Duration: March 20 – April 13, 2017

Covers Removed

- All covers were removed April 13th
- Once covers were removed, TCE concentrations rebounded to previous levels

TCE Concentrations After Removing Conduit Covers



TCE Results In Breathing Zone After Uncovering Conduits

	TCE CONCENTRATIONS SUMPS UNCOVERED		
	Minimum Conc. $\mu\text{g}/\text{m}^3$	Maximum Conc. $\mu\text{g}/\text{m}^3$	Average Conc. $\mu\text{g}/\text{m}^3$
BACK	2.8	16.6 *	8.0
BZD-22	4.2	19.6 *	9.7 *
BZD-24	4.4	19.8 *	10.3 *
BZD-26	5.4	21.7 *	11.1 *
BZD-28	2.3	19.8 *	7.5
		* Exceeds TCE IA VISL 8.8 $\mu\text{g}/\text{m}^3$	

Sampling Duration: April 13 – April 18, 2017

Subsequent Steps

- Short-term steps accomplished:
 - Sealed duct work to the main floor
 - Added permanent covers over sumps
 - Connected existing sub-slab vapor treatment system to extract vapors from sump
- Long-term:
 - Evaluating source remediation
 - Removing water from sumps
 - Future soil remediation



Summary of Tools Used

- Vapor Intrusion Monitoring
 - Summa canisters
 - Vapor pins and sub-slab samples
 - Indoor air breathing zone
 - Frog-4000™ gas chromatograph survey
 - Continuous gas chromatography / electron capture detector (GC/ECD)
- Vapor Mitigation
 - Installed indoor air purification units
 - Sealed conduits where vapors may enter
 - Connected sumps to sub-slab depressurization systems

Conclusions

- When indoor air concentrations are close to a health-based screening level, an 8-hour or 24-hour Summa sample may not be representative enough to provide a complete understanding of building compliance
- Continuous sampling over the course of 2 months provided an understanding of the fluctuations and ranges of breathing zone indoor air concentrations as well as VOC concentrations within subfloor sources
- 8-hour Summa canister sampling results were comparable to continuous sampling, but not necessarily representative, given the variable conditions
- Frog-4000™ gas chromatograph survey helpful in identifying sources, but not comparable to either 8-hour Summa or continuous sampling



Questions?

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