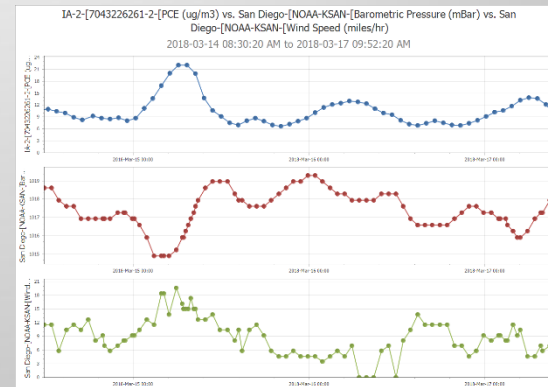
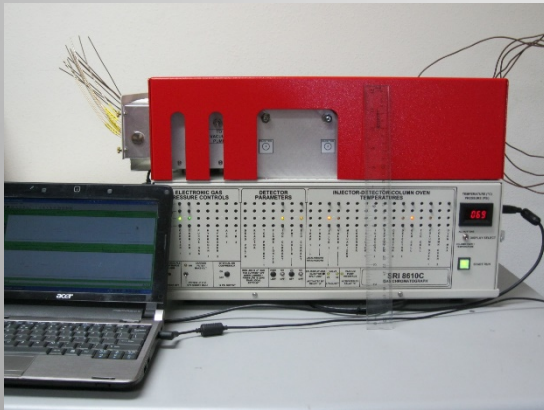


Resolving Vapor Intrusion Challenges via Automated Continuous Real-Time Monitoring and Response



Blayne Hartman Ph.D.
858-204-6170
www.hartmaneg.com

Mark Kram, Ph.D.
805-899-8142
www.groundswelltech.com

HARTMAN
ENVIRONMENTAL GEOSCIENCE

GROUNDWELL
EARTH MONITORING SOFTWARE

Presentation Summary

- Current Hot Topics in the VI World
- High Resolution Continuous Monitoring

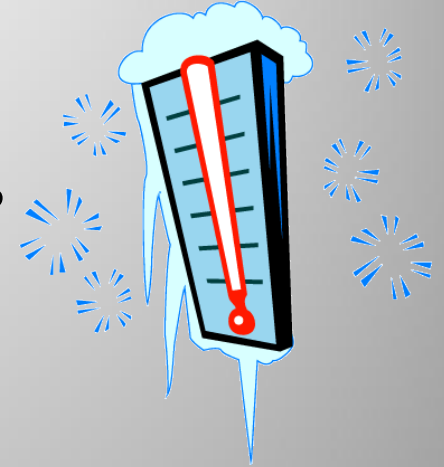
Why is VI Such A Concern?

- Long distances (100s of feet)
- Lots of compounds (80+)
- Low screening levels (< 1 ppbv)
- Lots of receptors (people, animals, fruit)

Regulatory Topics

Getting Cold

1. EPA OSWER & OUST Guidances
2. ASTM Phase 1 Standard
3. ITRC PVI Guidance

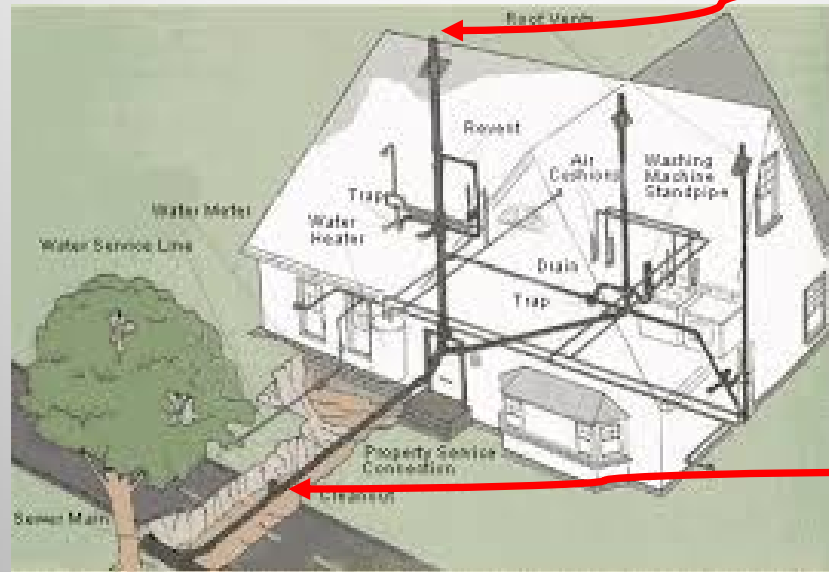


Red Hot

4. Sewers
5. Indicators of VI
6. Models/Attenuation Factors
7. Short Term TCE Exposure



Sewers

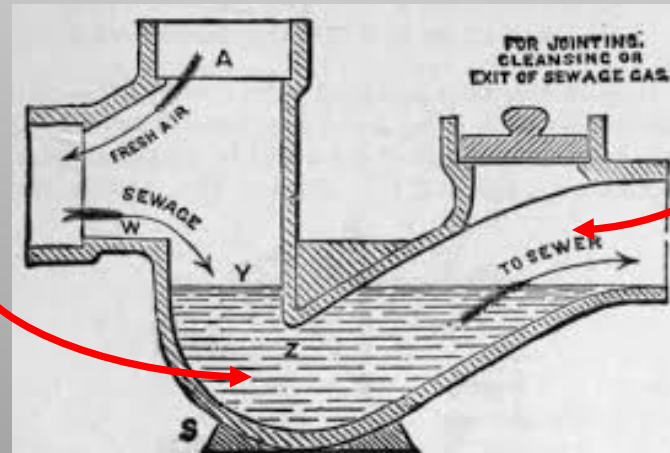


Roof Vents

Easy to Sample

Clean-outs

Easy to Prevent
(Keep Wet)



P-Traps



VI Indicators?

Can we use some easy to measure variable to predict when VI is occurring?

- Wind Speed?
- Barometric Pressure?
- Temperature Change?



EPA held a session on this topic in March 2017 & 2018

But why would you want to do this?



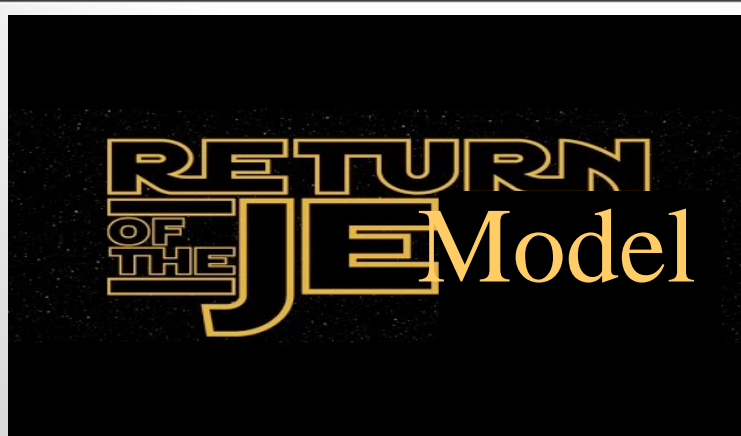
Modeling Getting the Boot

- EPA
- CA ??
- NY
- WA
- GA
- MO
- OH
- KS



Is this Paul
or Robbie?

VISL Intended to Replace Modeling



- New J-E Excel Released 9/2017
- Text on ReadMe Page: “**The J&E model does not replace the EPA VISLs.** For initial site screening, please refer to the VISL spreadsheet tool.”
- Quick Model Run. TCE, Subslab, 1e-6
 - Residential: 82 ug/m³; VISL: 16 ug/m³
 - Commercial: 350 ug/m³; VISL: 100 ug/m³

Can We Make it More Confusing?

CA Agencies Update

- VI Guidance Update to be Released Jan 2019
 - All agencies (DTSC, RWQCB, Counties, EPA R9)
- Adopting Att Factor of 0.03 for all Structures
 - Modeling allowed in some cases, but not as an exit
 - A task group trying to compile database on AF for CA
- At Least Two IA Sampling Rounds
 - And a third if data don't match
- Vapor Data Now to be Entered into Geotracker
- Water Boards Now Have a VI Page:

https://www.waterboards.ca.gov/water_issues/programs/site_cleanup_program/vapor_intrusion/

Should We Be Using 0.03?



EPA's Vapor Intrusion Database: Evaluation and Characterization of Attenuation Factors for Chlorinated Volatile Organic Compounds and **Residential** Buildings

EPA 530-R-10-002, March 16, 2012

- Residences with basements (95th):
(0.03)
- Residences with slab-on-grade (95th):
(0.01)

New Default: 0.03 for All Structures!



The Hottest VI Regulatory Topic

Short Term TCE Exposure





Johnson et al Study (2003)

- Fetal heart malformations observed during 21-day gestational period of Sprague-Dawley rat based on oral exposure.
- To date, fetal heart malformation results not replicated in other studies, including: FIVE TCE rodent/rabbit inhalation studies
 - Carney et al., 2006
 - Dorfmüller et al., 1979
 - Hardin et al., 1981
 - Healy et al., 1982
 - Schwetz et al., 1975



New TCE Study Status

TCE drinking water study designed to mirror 2003 Johnson study currently underway (sponsored by American Chemical Society & Solvent Industry):

- Lab Studies concluded in August 2018
- Evaluation of Data currently ongoing
- Report by end of 2018

EPA R7 Short Term TCE Guidance

- EPA Region 7, November 2nd, 2016
 - *"It is assumed that an exposure to TCE at any time during an approximate three-week period in early pregnancy could result in one or more types of cardiac malformations."*
 - 2 ug/m³ – 24 hour period (residential)
 - 6 ug/m³ – 8 hour (commercial)
- Does this mean the following:
 - 48 ug/m³ – for 1 hour?
 - 96 ug/m³ – for 30 minutes?
 - 480 ug/m³ – for 6 minutes?

States Reopening TCE Sites

- MA
- MI
- OH
- NY
- NJ
- CA?



And this means:





VI Assessment Topic

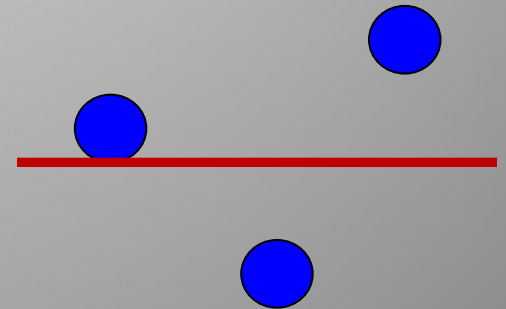
High Resolution VOC Data

The Fundamental Problem with VI Assessments & Remedies:

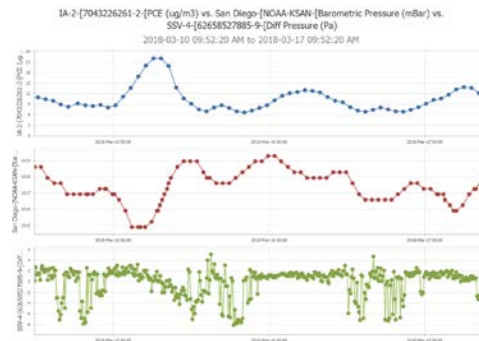
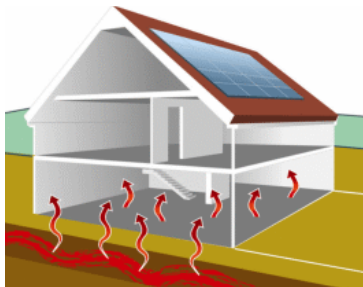
With These:



You Get



Automated Continuous Vapor Intrusion Monitoring and Response



Mark Kram, Ph.D. (Groundswell)

Blayne Hartman, Ph.D. (HEG)

Cliff Frescura (Groundswell)

October 30th, 2018

Presentation Summary

- Why Continuous Monitoring?
- Technology Description
- Data from Real Sites
- Lessons Learned

Background/Motive

- Short Term TCE Risk Driver
 - 24 hours? A few days? 21 days? Shorter?
 - Rapid Response Requirements
- CA Supplemental Guidance; Others
 - Acknowledge Dynamics, De-Emphasize Models
 - Default AF of 0.03 ($\text{TCE}_{\text{Screen(Can)}}$: SS/SG=16 $\mu\text{g}/\text{m}^3$, 100 $\mu\text{g}/\text{m}^3$)
 - More Indoor Sampling/Monitoring
- Mitigation/Remediation
 - Need for Confirmation/Optimization/Emission Protection
 - Ensure Immediate Response to Acute Risks

Background/Motive

(Forand et al., 2012)

There is evidence suggesting adverse health effects in at least one community subject to vapor intrusion exposures posed by PCE and TCE:

- Maternal residence in both areas was associated with cardiac defects.
- Residence in the TCE area was also associated with low birth weight and fetal growth restriction.

Reference: <https://www.ncbi.nlm.nih.gov/pubmed/22142966>

Background/Motive

- SBA's Drycleaner Requirements [SOP 50 10 5 (J)]:
 - Phase I and II ESA Required
 - VI Component
 - Need for Quick Answers

“Prudent lending practices dictate and SBA requires that any Property with on-site dry cleaning facilities, whether currently in operation or operated historically at the site, that did, do or likely used chlorinated and/or petroleum-based solvents undergo a Phase II ESA...Any soil and groundwater contamination and soil vapor intrusion must be addressed.”

https://www.sba.gov/sites/default/files/2017-10/SOP%2050%2010%205%28J%29_FINAL_.pdf

Short-Term TCE Assessment Options

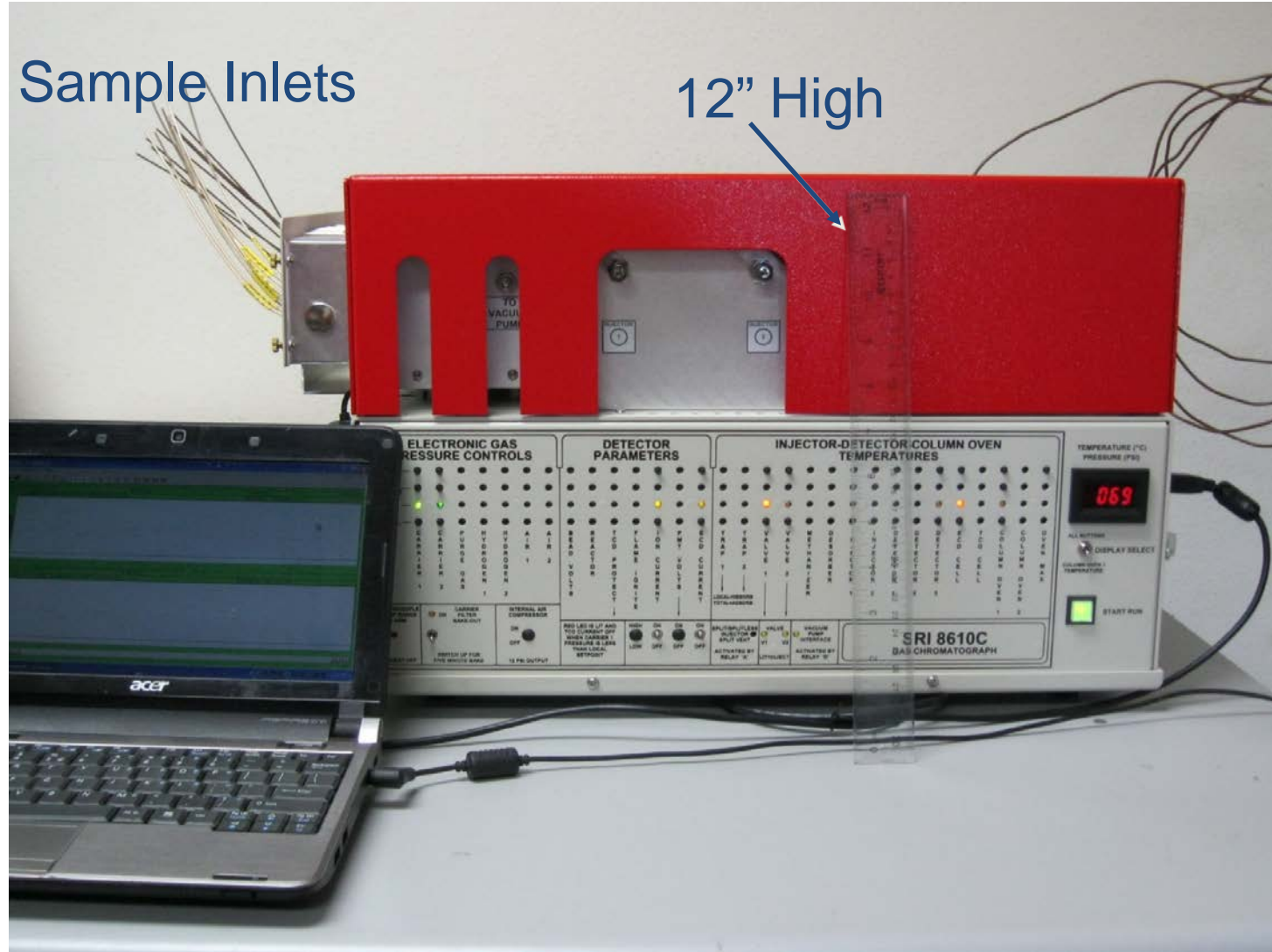
- Long Term Passive/Canister Sample
 - One number over sampling period
 - Can't see the pattern
 - No real-time feedback, acute TCE risks
 - False negative/positive possible
 - Costly if multiple rooms, multiple events
- Continuous Analyzers
 - Can determine duration: Hours? Days?
 - Can see the pattern! Day vs. Night? HVAC? Breakthrough?
 - Immediate response – Occupant H&S, liability
 - Single mobilization

VaporSafe™ Continuous Monitoring System

VAPOR INTRUSION
ASSESSMENT, MONITORING & RESPONSE SERVICES

Sample Inlets

12" High



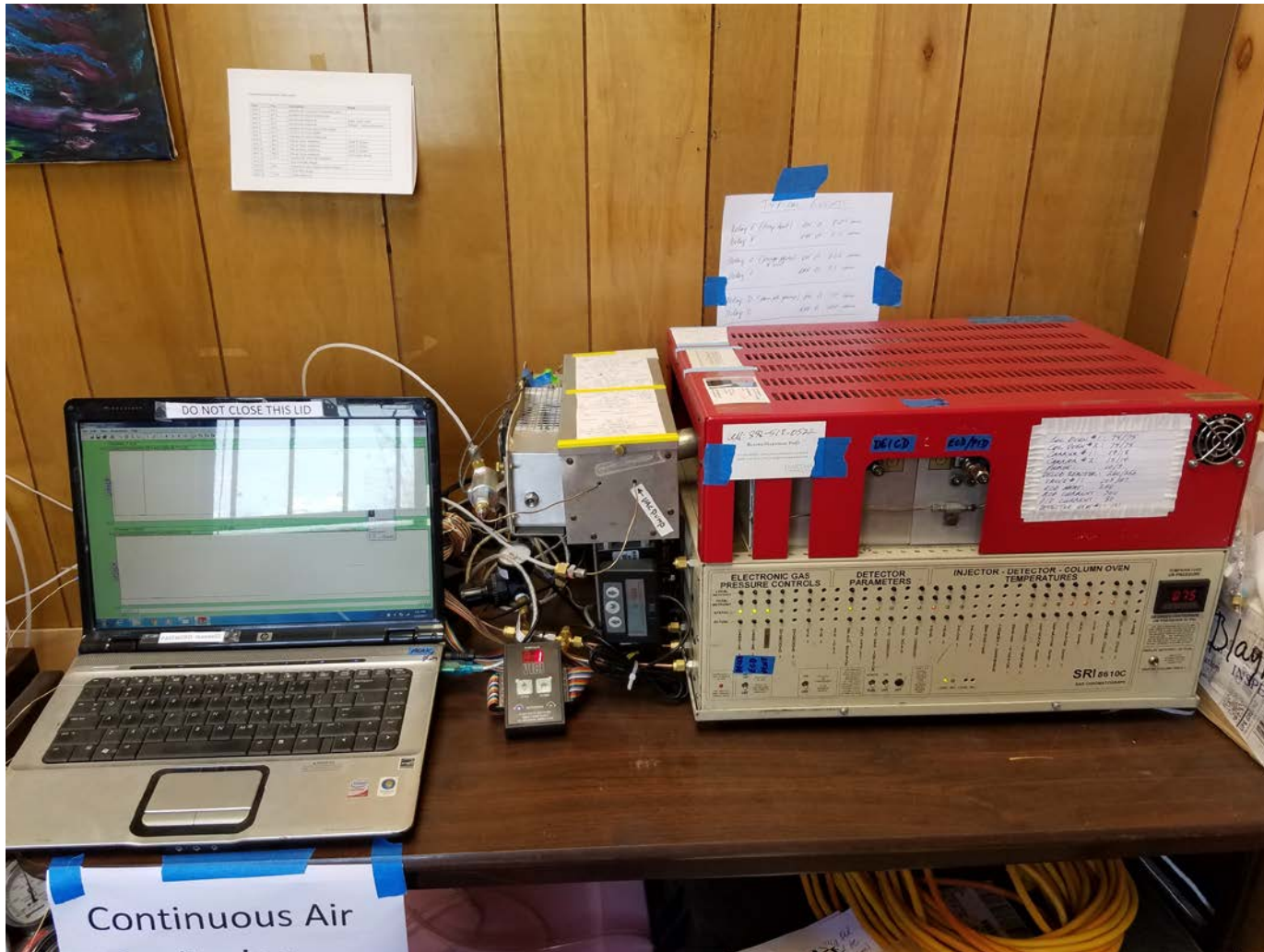
System Capability

- **Fully Quantitative!**
- Can Reach Ultra-Low Levels (<1 µg/m³) for TCE, PCE, VC & others
- <10 min Analysis Time
- Multiple Sample Locations (16 to 30)
- Modified EPA Method TO-14A
- Stable - holds calibration for months
- Remote Control
- Real-Time Data/Response
- Discrete Mode

CM Confirm/Optimize/Protect

- Mitigation
 - HVAC Controls
 - Fans On/Off
 - Air Filtration Units
 - Sealing Sumps & Cracks
 - Sub-Slab Depressurization Systems
 - Building Manipulations
- Remediation
 - In-Situ GW/Soil Remediation/ISCR/ISCO
 - Thermal/SVE
 - Fugitive Emissions (VOCs, Methane)

Field Images



Field Images



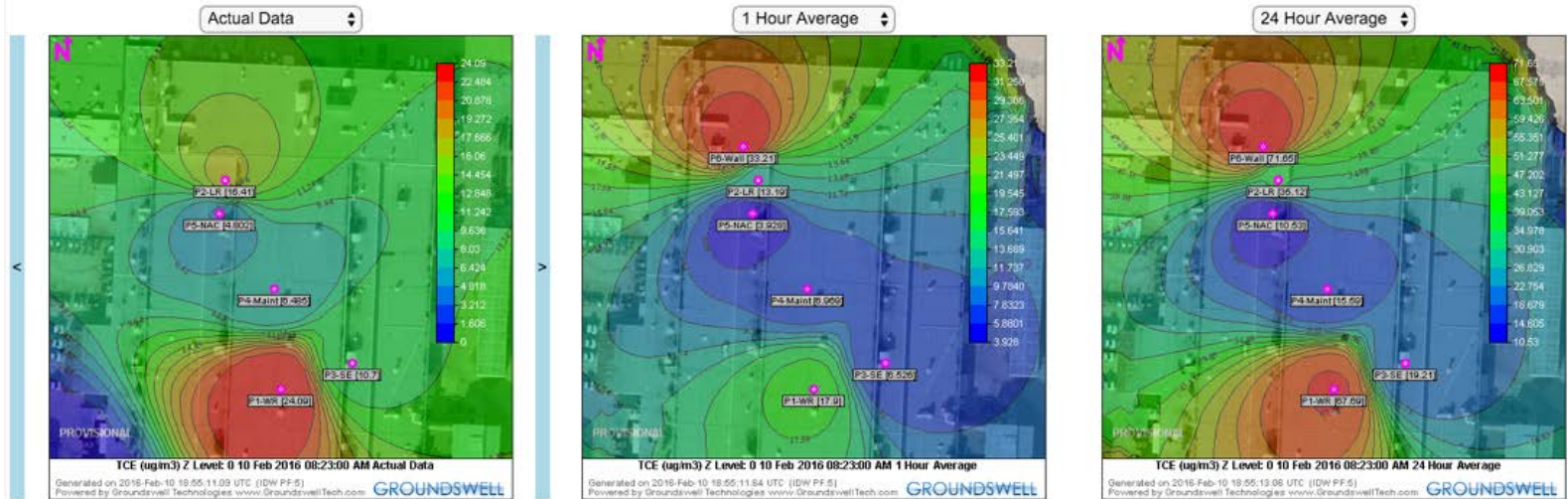
Data

- Concentrations
- Pressure Differential
- Barometric, Temp., Wind Speed, etc.
- Dashboard
 - Time Series
 - Stacked Time Series
 - Contour Images
 - Moving Averages
 - Alerting
- Trigger Relays
- All Web Based, Daily Reports

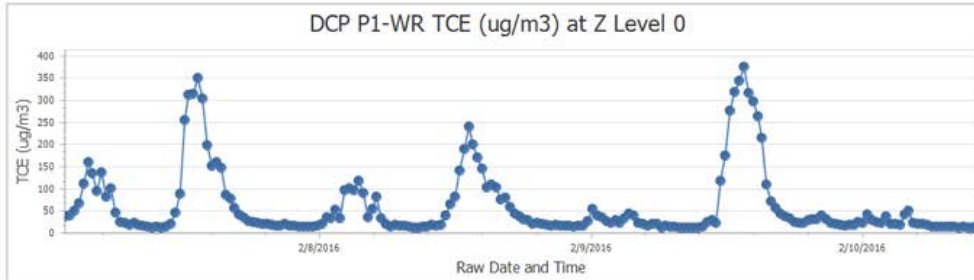
Monitoring/Response Dashboard

Data Channel **TCE (ug/m3)** 2016-02-10 10:22:29 AM **Jump to Time** **Jump to Most Recent Tir** Z Level: **0**

Show DCP Labels Show DCP Markers Map Type **Aerial** Map Opacity **55%** Visualization Type **IDW** Bin This Time Step



DCP: **P1-WR**



123 Alerts in the Last 24 Hours ([View All](#))

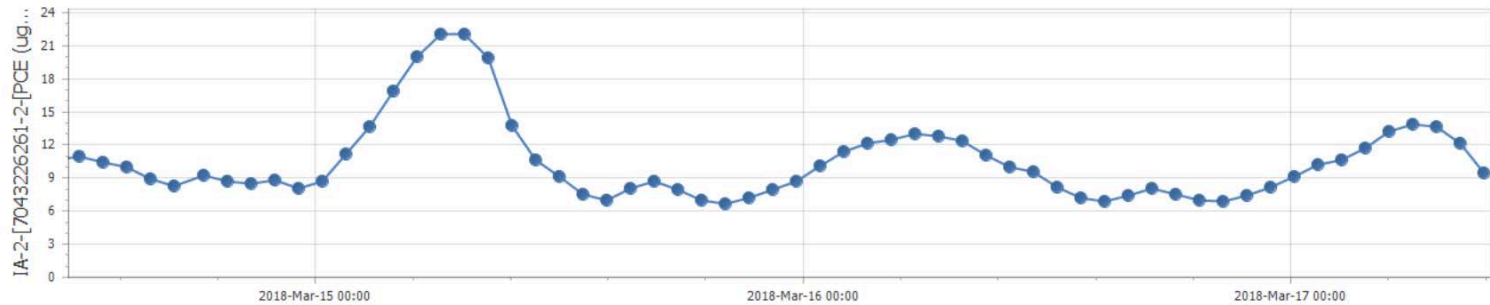
Raw Date Time	Norm Date Time	DCP	Alert Value
2016-02-10 10:34:38	2016-02-10 08:23:00	P1-WR	24.0905 TCE ug/m3
2016-02-10 10:30:35	2016-02-10 07:59:00	P6-Wall	34.1741 TCE ug/m3
2016-02-10 10:06:16	2016-02-10 07:35:00	P6-Wall	32.2501 TCE ug/m3
2016-02-10 08:28:59	2016-02-10 05:59:00	P6-Wall	25.5198 TCE ug/m3

Page 1 of 16 (123 items) < Prev 1 2 3 4 5 6 7 ... 14 15 16 Next >

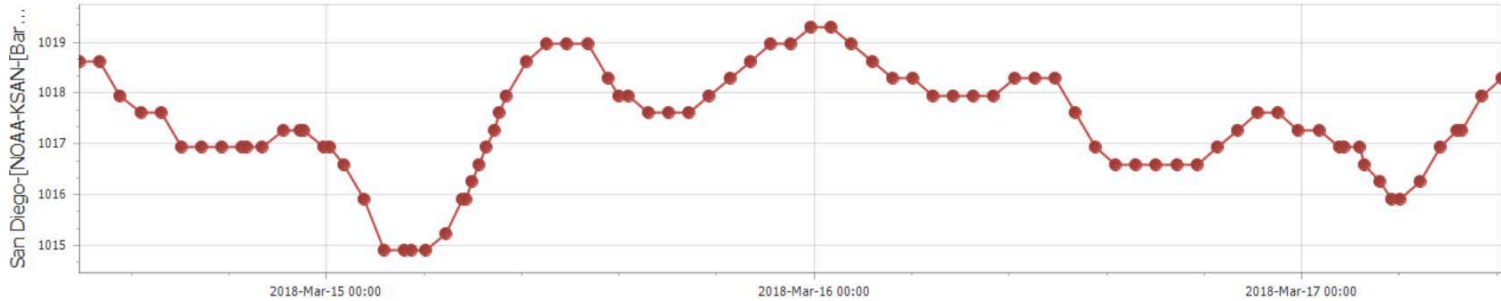
Stacked Time Series

IA-2-[7043226261-2-[PCE (ug/m3) vs. San Diego-[NOAA-KSAN-[Barometric Pressure (mBar) vs. SSV-4-[62658527885-9-[Diff Pressure (Pa)
2018-03-10 09:52:20 AM to 2018-03-17 09:52:20 AM

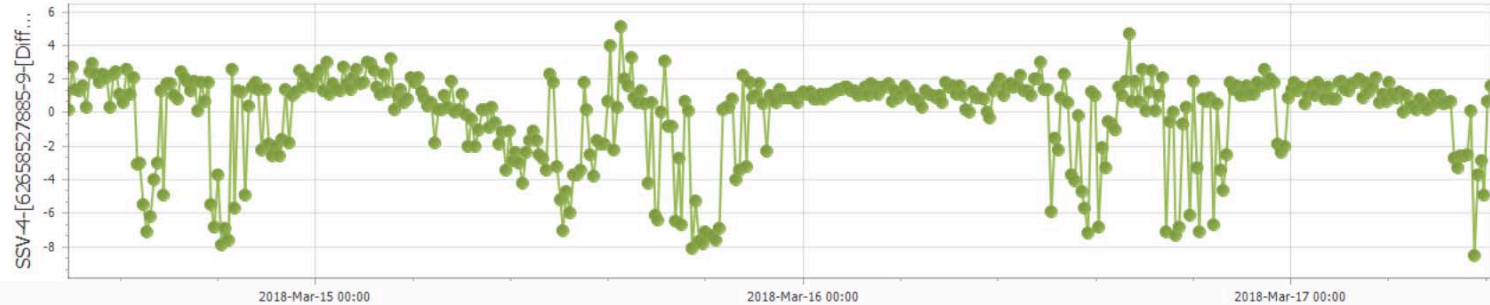
PCE



Baro



Diff P



Auto-Alerting/Response

Subject: [Groundswell Alert] Proj:NHBB Alert:TCEAlert DCP:ECD07 Reading:32.01 TCE ug/m3 at 9/7/2016 20:23:48

Importance: High

Groundswell Alert for Project NHBB

Alert Name	Alert Value	DCP	Event Date/Time	Alert Criteria	Low Trigger Value	High Trigger Value	DCP Notes
TCEAlert	32.0143 TCE ug/m3	ECD07	9/7/2016 20:23:48	Equal to or Greater Than (Data Value >= Trigger Value)	8.8	8.8	

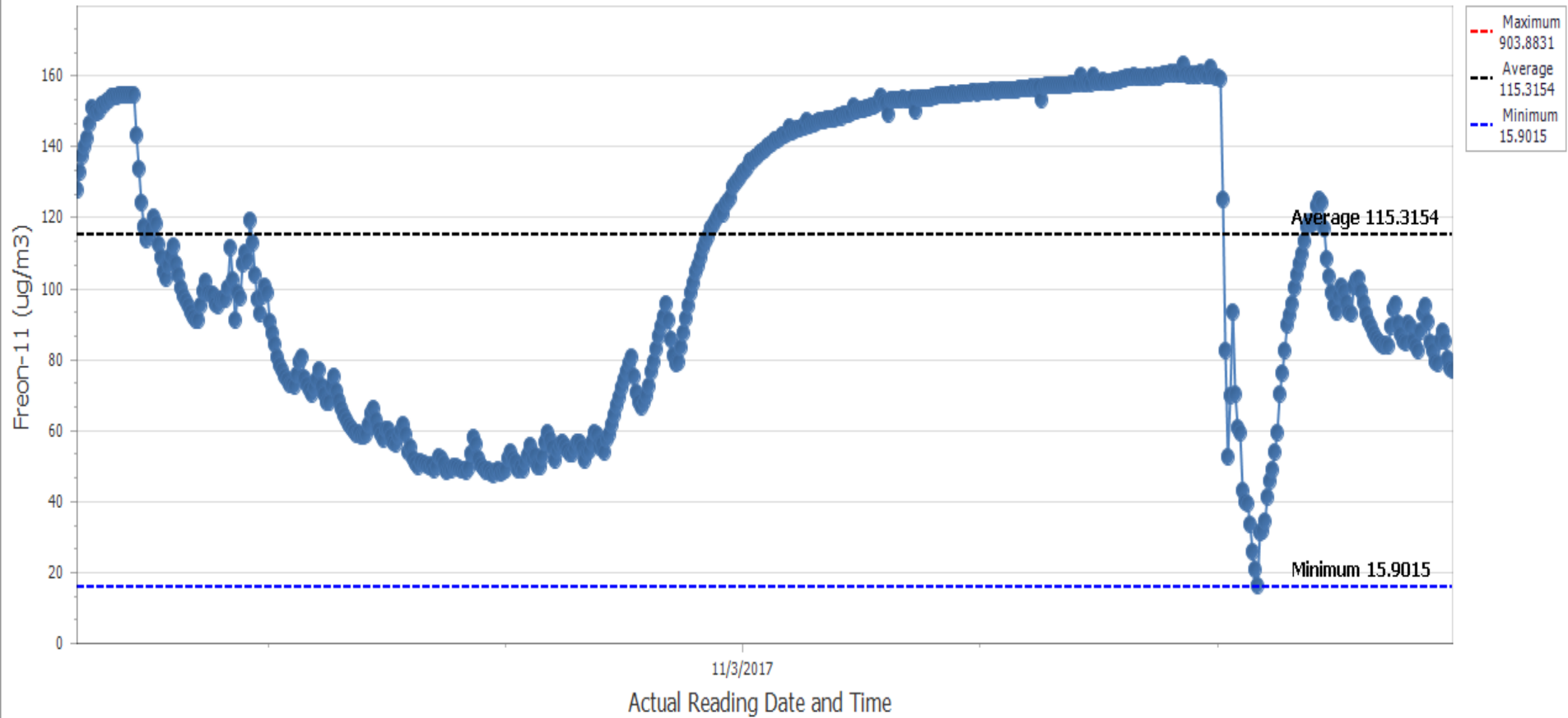
[Click here to view the Alert History](#) (account required)



Data Pattern = Opportunity

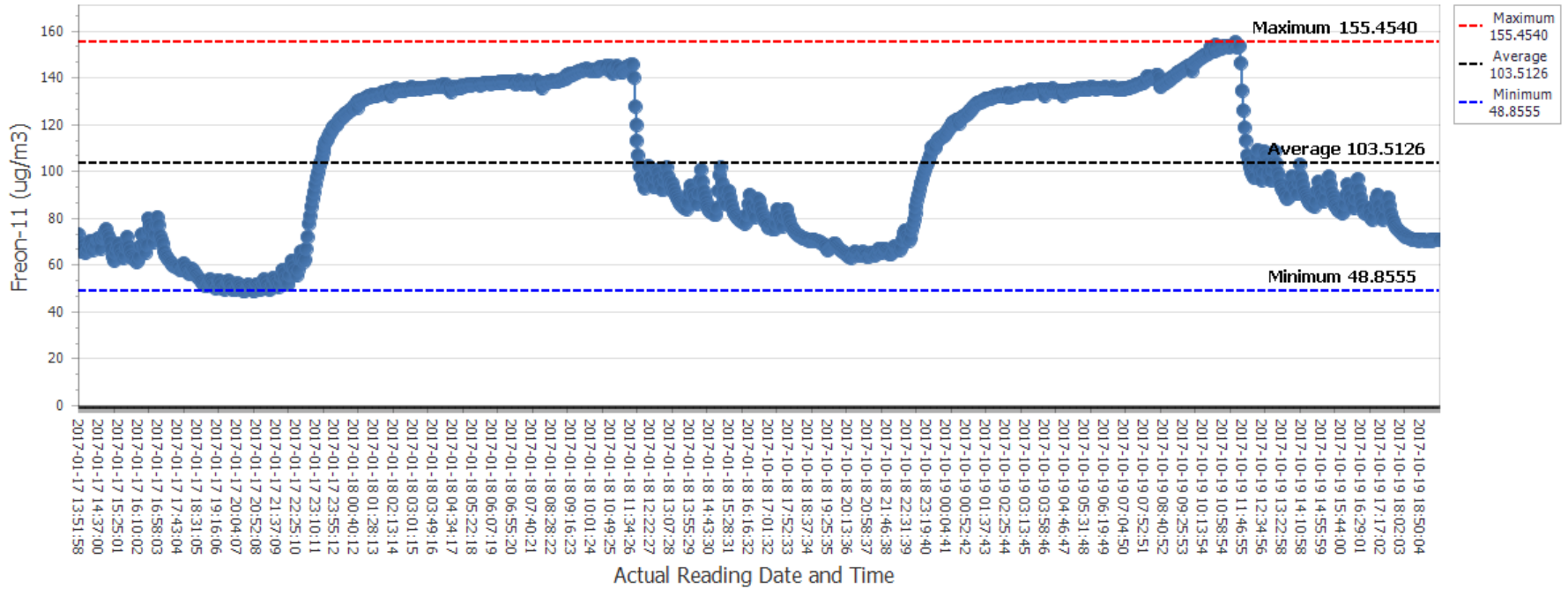
Freon 11 - Office Bldg – 1 Day

DCP Port-01 (Port1) Freon-11 (ug/m3)

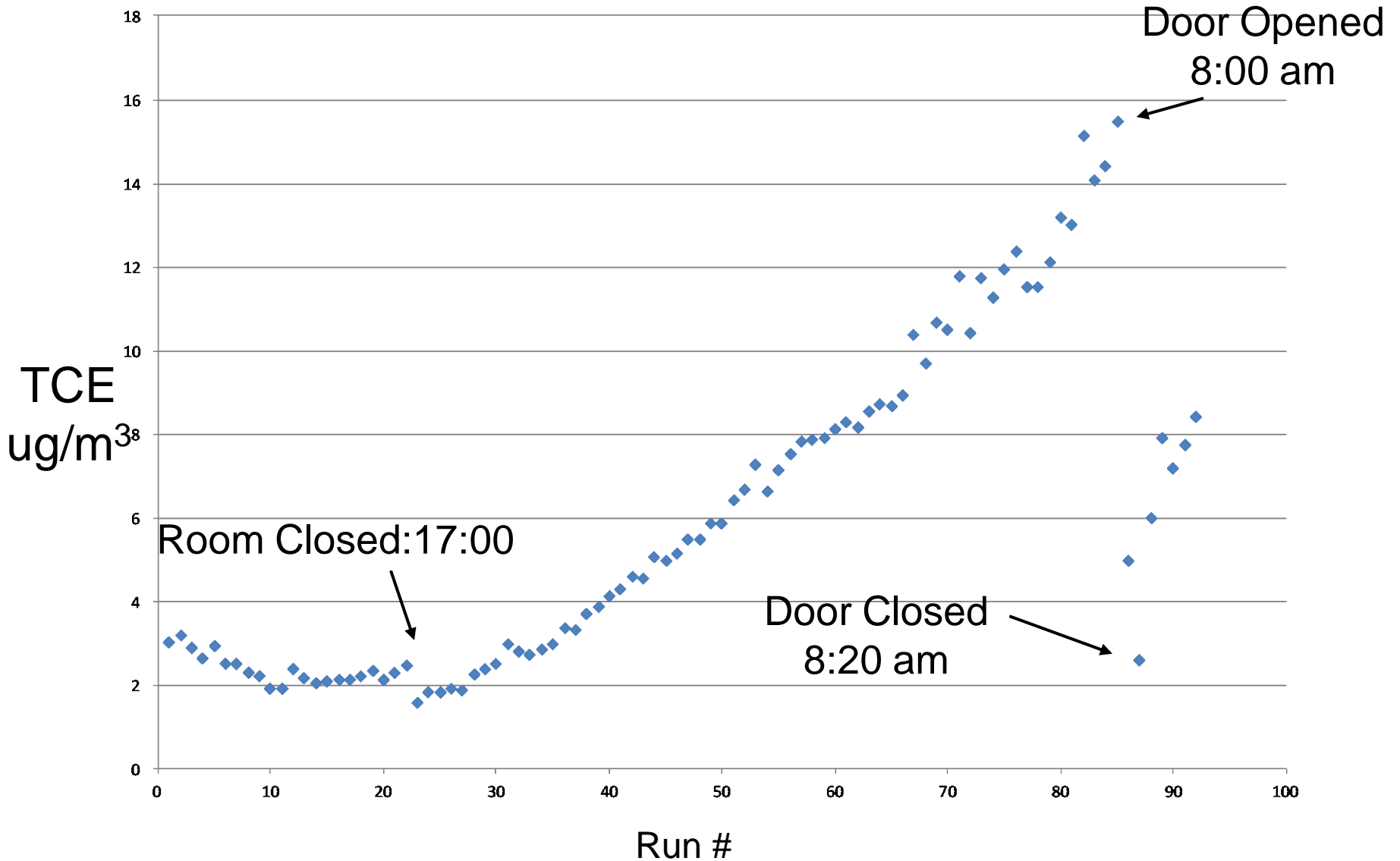


Freon 11 - Office Bldg – 2 Days

DCP Port-01 (Port1) Freon-11 (ug/m3)



Close Door

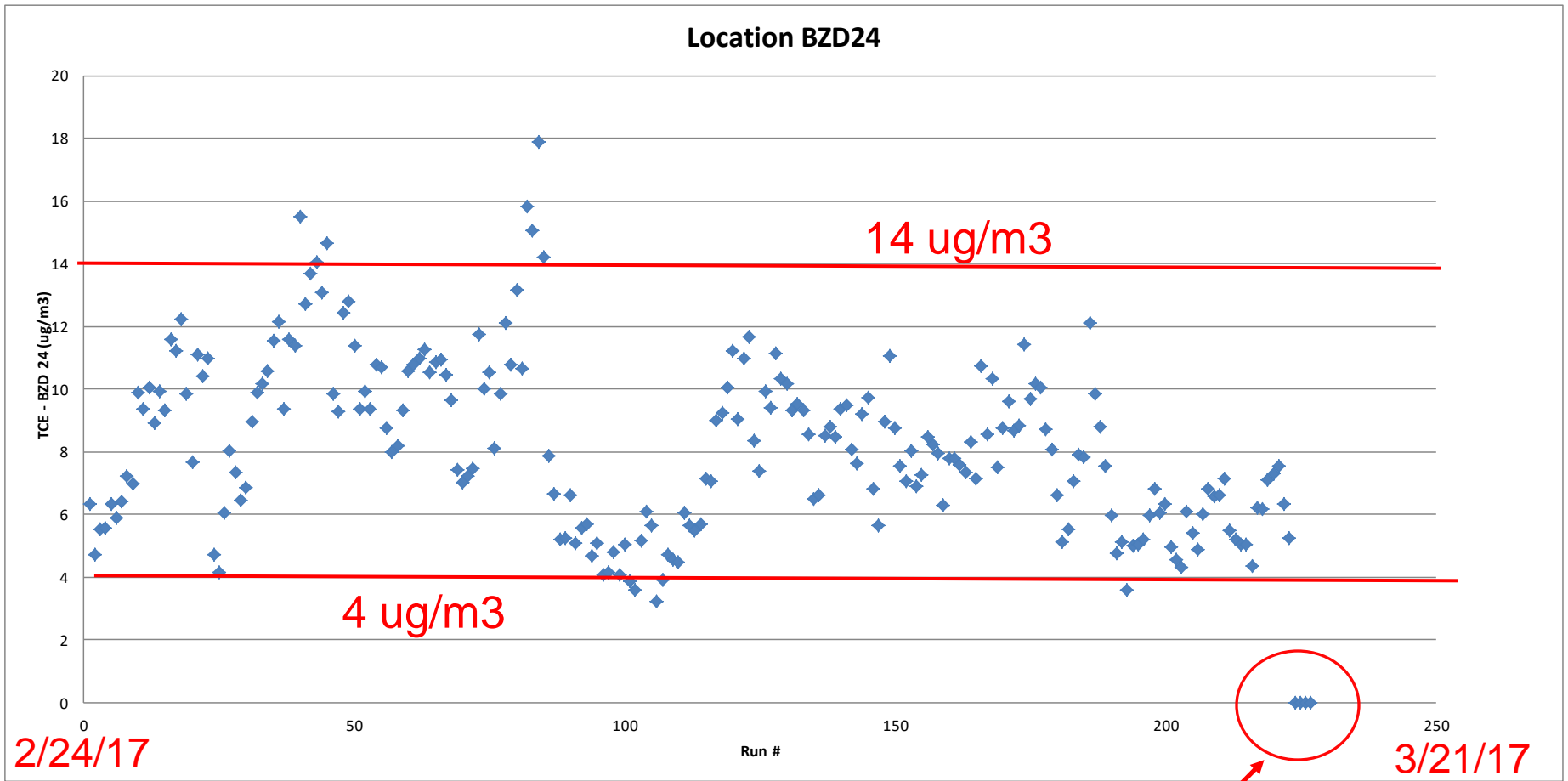


Lessons Learned

Close Door

- Pattern is Key
- Determine VOC Entry Points within 12 Hours
- Can Estimate Mass Flux
- Instant Recognition of Bldg Manipulation
- Remedy Obvious: Seal Drain and Extract

Seal Sumps



Lessons Learned Seal Sumps

- Pattern is Key
- Temporal Variation ~ 3.5x
- Highest Conc Areas Known Within 12 Hours
- Instant Recognition of Bldg Manipulation
- Remedy Obvious: Seal Sumps & Extract



Expedited VI Assessments

- Can see pattern within days
- Can determine if from VI or indoor source
- Can determine cause & effect
- How often above screening level

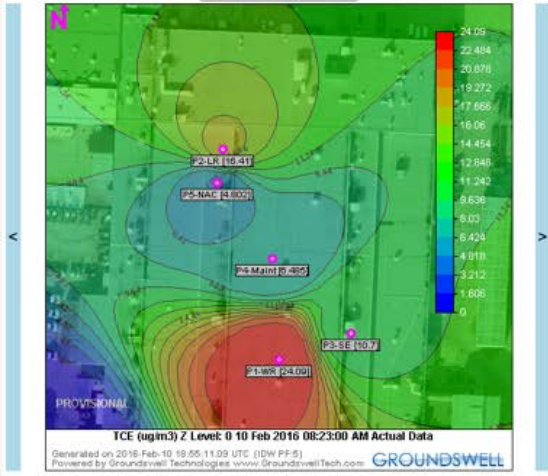
Pattern = Opportunity

Large Industrial Facility

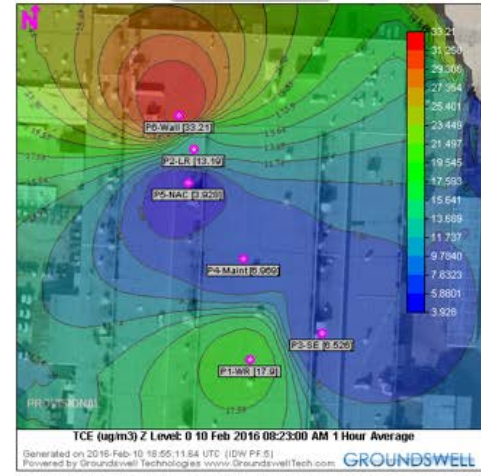
Data Channel TCE (ug/m3) 2016-02-10 10:22:29 AM Jump to Time Jump to Most Recent Tir Z Level: 0

Show DCP Labels Show DCP Markers Map Type Aerial Map Opacity 55% Visualization Type IDW Bin This Time Step

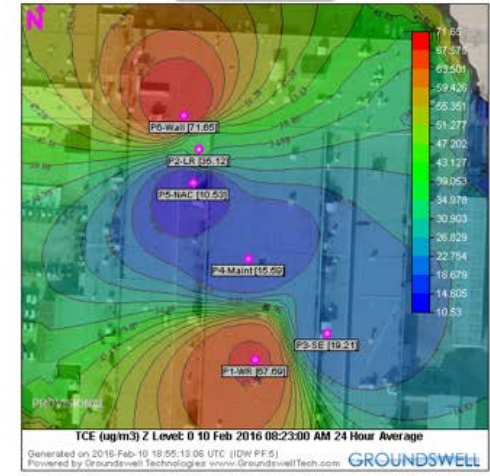
Actual Data



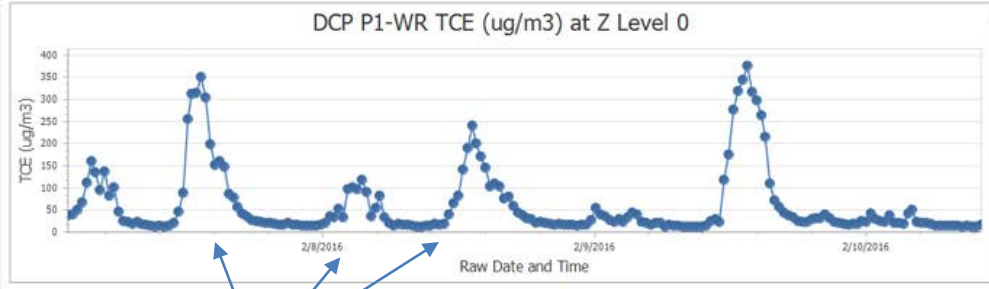
1 Hour Average



24 Hour Average



DCP: P1-WR



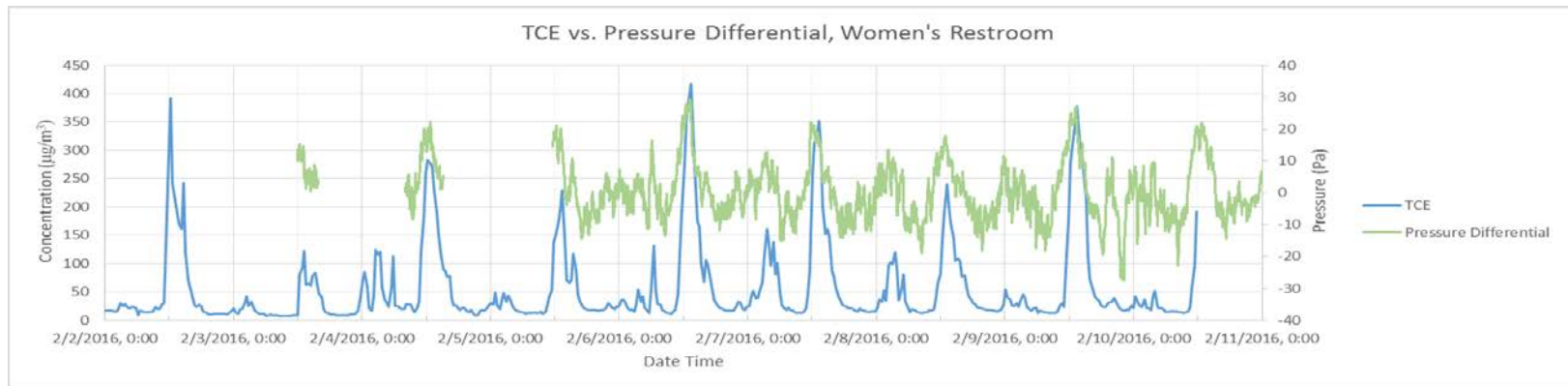
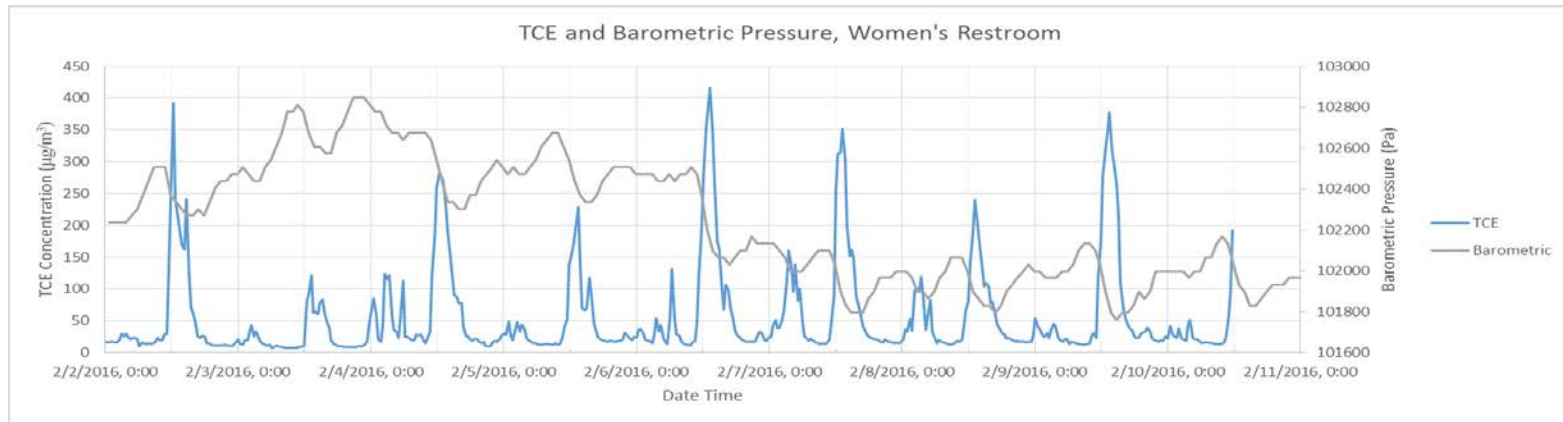
123 Alerts in the Last 24 Hours (View All)

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2016-02-10 08:28:59	2016-02-10 05:59:00	P6-Wall	25.5198 TCE ug/m3

Page 1 of 16 (123 items) < Prev 1 2 3 4 5 6 7 ... 14 15 16 Next >

Mid Morning, Late Eve Peaks

Large Industrial Facility



Daily BP Change 🖱️ Slight Pressure Diff 🖱️ VI

Hosangadi et al., 2017, *High Frequency Continuous Monitoring To Track Vapor Intrusion Resulting From Naturally Occurring Pressure Dynamics*, Journal of Remediation, Spring, v.27, no.2, p.9-25.

Lessons Learned Industrial Facility

- Pattern is Key!!
- TCE Temporal Variation of 50x
- Elevated Values for 6 to 12 hour periods
- Highs Correlated with Sub-Slab Pressure
- BP trend & PD >> BP
- Confirmed SVE Working!

Wireless Press Diff



P Diff

Sends to Base Station

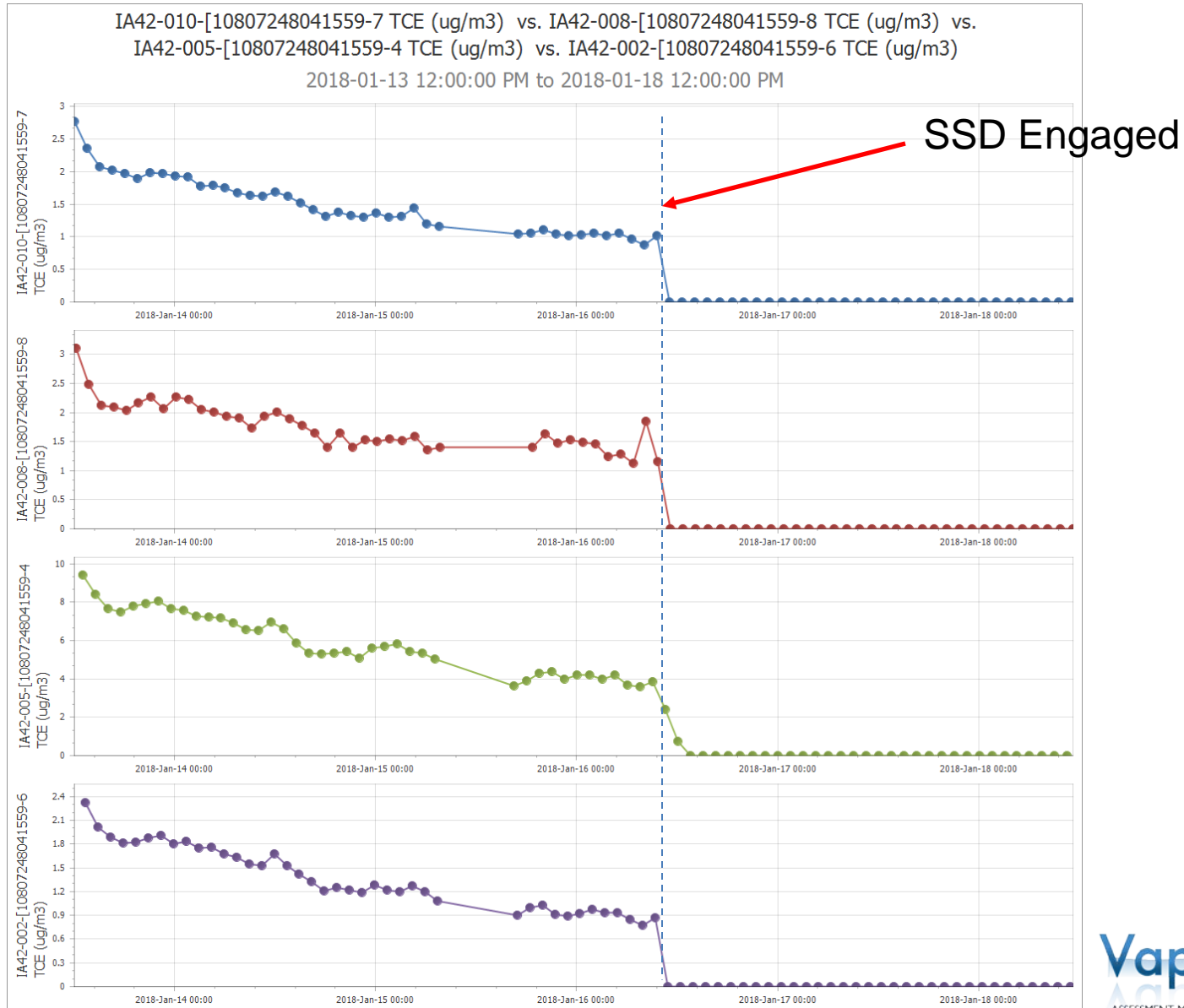
Real-Time Web Review/Alert

To
SS Port

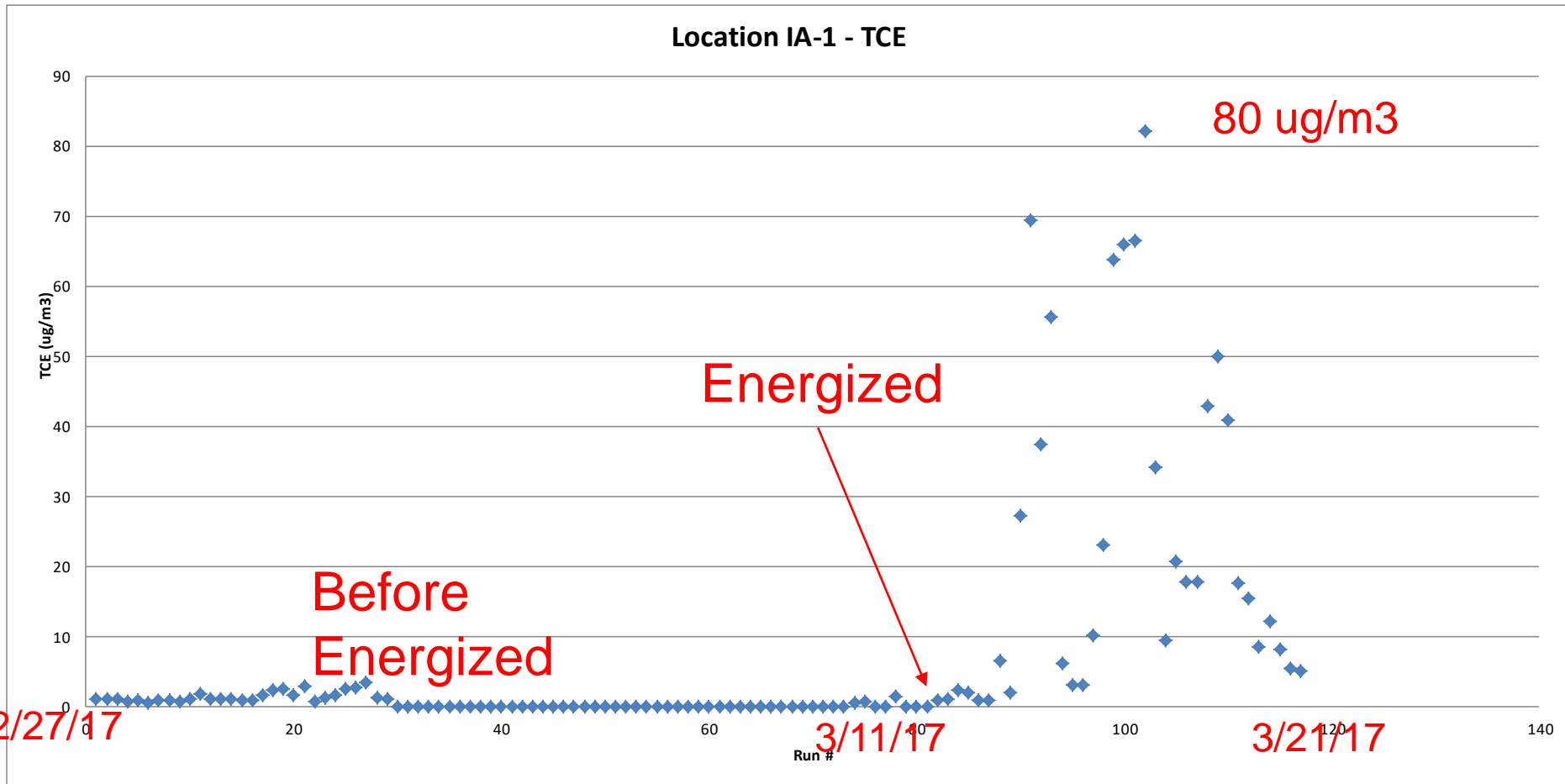
Coupled to Chem Data

Antenna

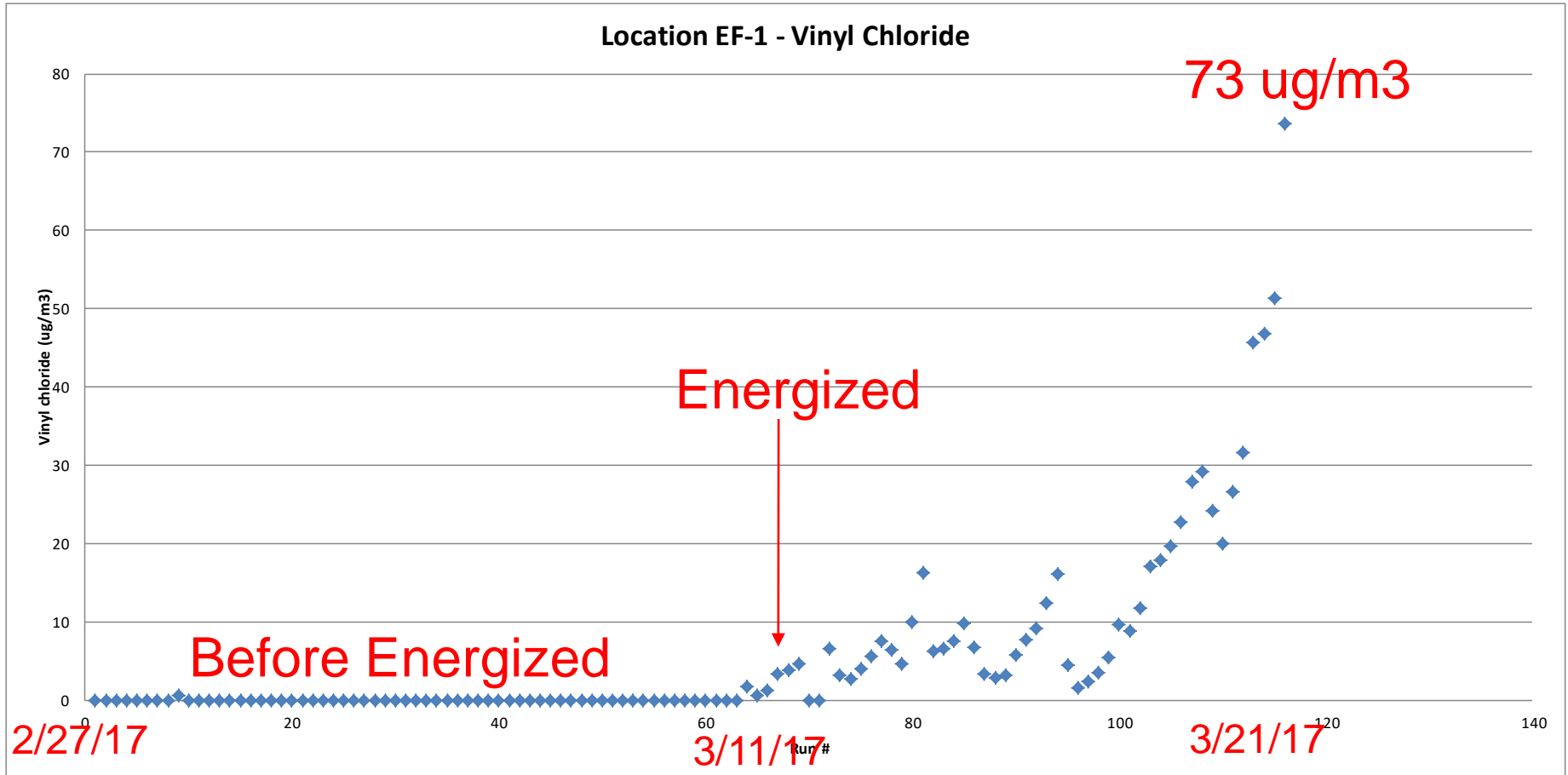
Proving SSD Remedy Effectiveness



TCE – Warehouse Air ERH System Start-Up



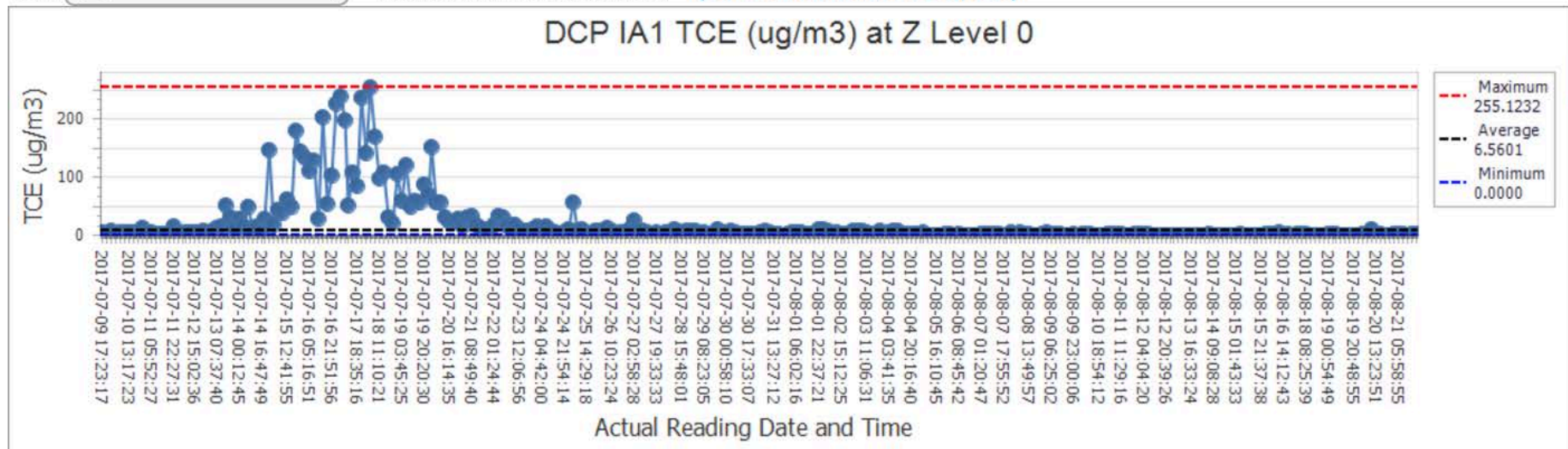
Vinyl Chloride – Effluent



TCE – Warehouse Air Adaptive Response

DCP: IA1

Warehouse IA, Glass Room [\(Click here for additional plots\)](#)



Lessons Learned

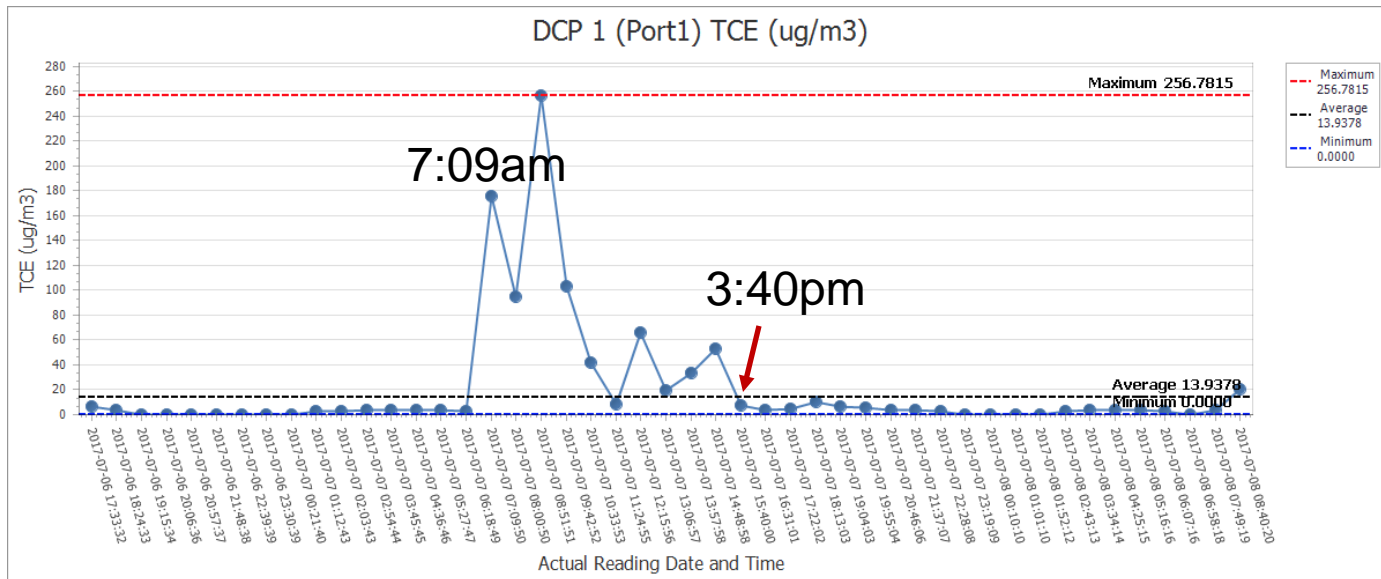
Thermal Remediation

- TCE & VC Increases Seen Within Days of Energizing
- Instant Recognition of “Leaks”
- Vapor Recovery Adjustment/Optimization
- 13 Locations Monitored: Multiple Buildings, Effluent, etc.
 - Cal Runs Every Cycle
- Automated Alerting, Response Triggers
- Cost Effectively Met Adaptive Objectives – 11 Months!
- First Time Ever VC Monitored Continuously
- Integrated with EPA VIPER
- Only Continuous Monitoring Allows for Immediate Response

Furniture Facility

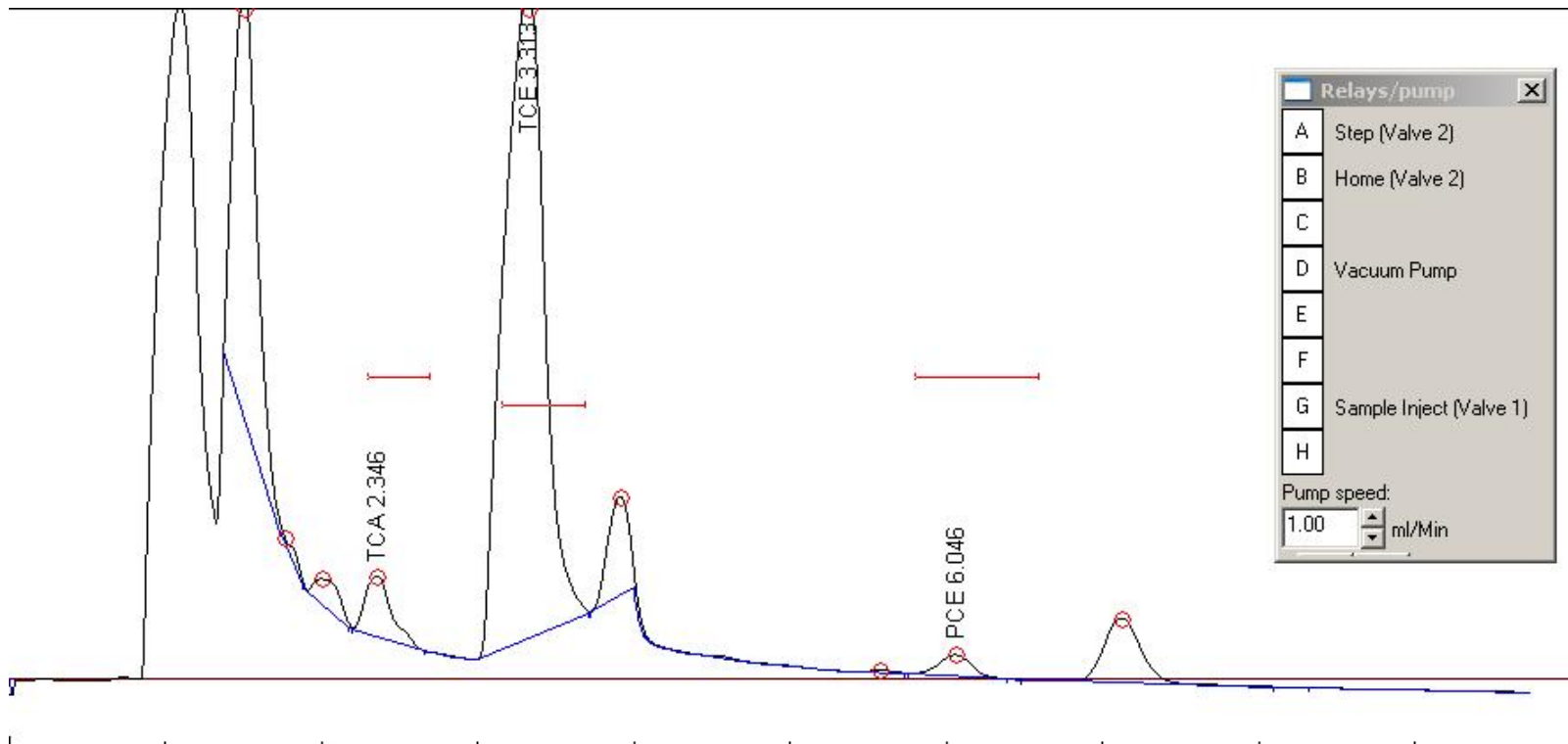
Rapid Resolution

- Building for Sale
- Owner “Low-Balled” by \$2M - Assumed VI (SS TCE/PCE)
- Indoor TCE Only During Work Hours; Pattern Ubiquitous



Furniture Facility

Silicone Spray Chromatogram



Indoor PCE/TCE Ratio << Subsurface Ratio

Lessons

- Concluded No VI (via MLE)
- Traditional Methods = Mystery, Costs, Exposures
- Continuous Monitoring = Accurate Sourcing
- Uncertainties Quickly Resolved, Remedy Obvious
- Protected Occupants
- Saved Owner \$2M

Summary

With



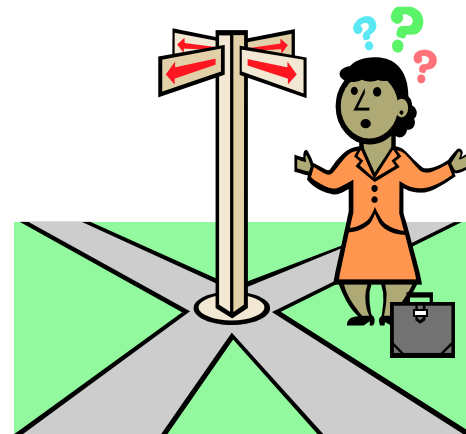
You Get



With



You Get



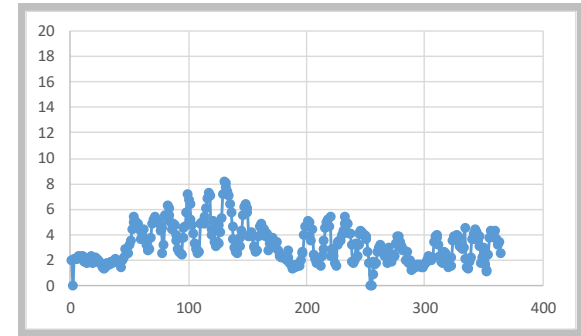
And More Time & Expense

Summary

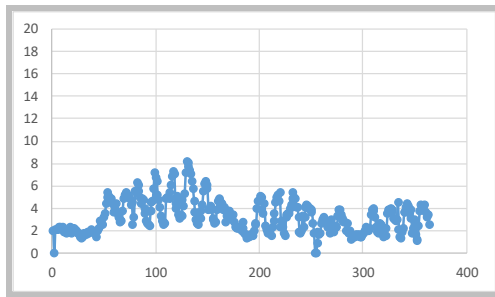
With



You Get



With



You Get



Summary/Opportunity

- Monitoring/Response/Confirm Technology Exists
- TCE, PCE, VC, etc., Methane (>140 Results/Day)
- Pattern = Opportunity!
- Rapidly Address in Single Mobilization:
 - No risk situations
 - TCE accelerated/urgent exceedances
 - VOC entry locations, preferential pathways
 - Effectiveness of mitigation systems
 - Effectiveness/optimization of remediation systems
 - Brownfield concerns (resolve during escrow)
- Prevent Acute TCE Exposures!

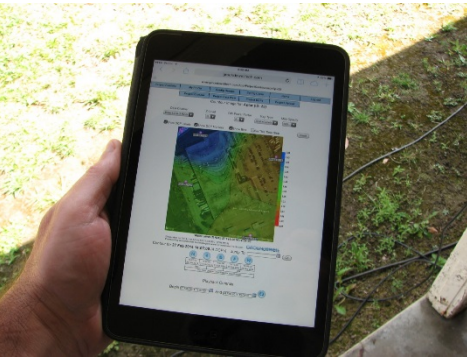
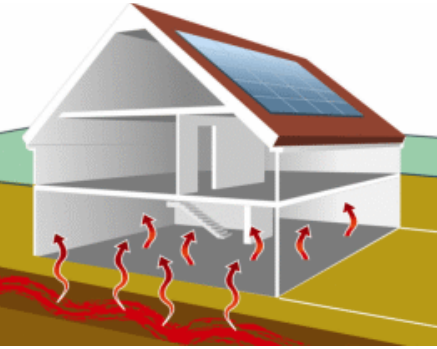
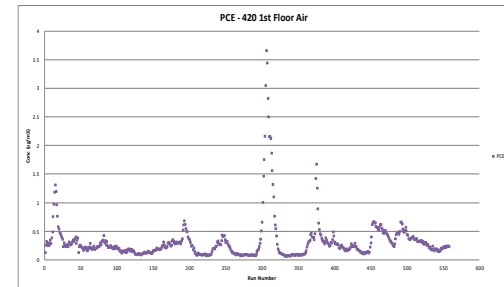
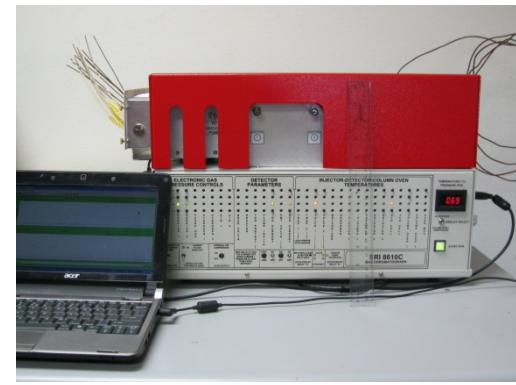
Obvious Questions:

- **What Does it Cost?**
 - ✓ \$1000 - \$2000/day (~\$10/analysis; >140/day)
 - ✓ 10 Canisters: ~\$5000 (often higher with reporting)
 - ✓ Consider Value (e.g., proceed to next step)
- **Do Agencies Accept?**
 - ✓ EPA Regions 1, 9, 10
 - ✓ CA, NH, IN, AZ, MA, Navy, etc.
 - ✓ Upcoming: EPA-R5, NC, USAF, ACOE, International
- **How Do Results Compare to TO-15?**
 - ✓ No Complaints To-Date

Questions?

Mark Kram, Ph.D.
mark.kram@groundswelltech.com

Blayne Hartman, Ph.D.
blayne@hartmaneg.com



GROUNDSWELL
EARTH MONITORING SOFTWARE

VaporSafe™ ✓
VAPOR INTRUSION
ASSESSMENT, MONITORING & RESPONSE SERVICES

HARTMAN
ENVIRONMENTAL GEOSCIENCE

System QA/QC

- Calibrated with Validated Gas Standards
- Minimum of 5 Calibration Points
- Can Run Calibration Gas Every Cycle of Ports
- Precision on EPA Indy Site: <10% over 100 Days
- Accuracy vs off-site TO-15: 17%

EPA Documented:

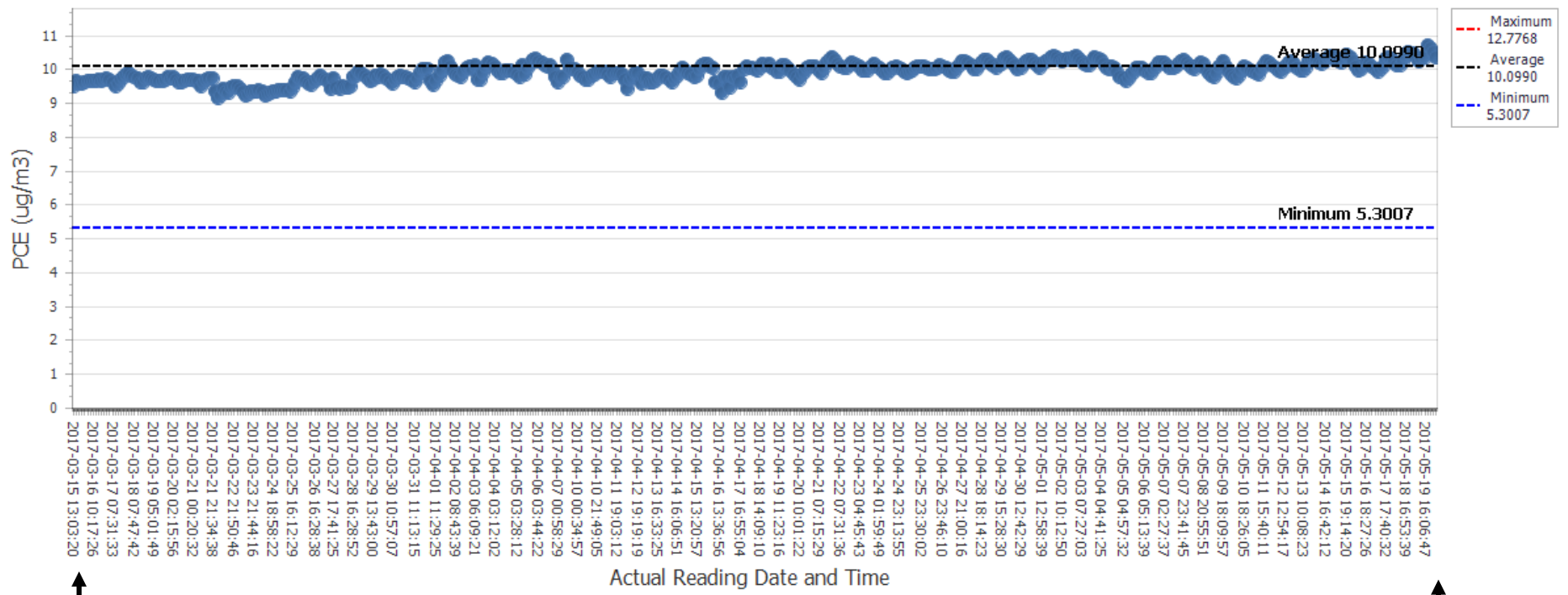
<https://clu-in.org/download/issues/vi/VI-EPA-600-R-13-241.pdf>

(EPA/600/R-13/241 | June 2015 | www.epa.gov/research)

ECD Calibration Gas Analyses

2 Months – Oakland Site

DCP TCE PCE Calgas (Port15) PCE (ug/m3)



3/15/17

5/19/17

- **GC Setup / Security**
 - Small footprint (~2' x 2' table required)
 - Some temperature control
 - Can make relatively stealth
- **Sampling Lines**
 - Up to 300m from instrument possible
 - Small diameter tubing (1/8" or 1/4")
- **O&M**
 - Conventional Wall Power (115v)
 - Change nitrogen every 3 to 5 months
- **Internet Connectivity**
 - Ethernet cable, site Wifi or cellular modem