Field Techniques & Strategies for Documenting Bioattenuation

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Bioattenuation of HCs

- Existing data suggest O_2 effective barrier
- Attenuation > 10,000 times
- DNA can confirm presence of tropic bugs
- How to Convince Regulators?
- How to Convince Public & Attorneys?

Regulatory Recognition of Bio

Agencies with Policy/Guidance

- EPA OSWER & OUST: Not Yet
- ITRC Survey: 9 States Allow for Bio
- Some States Account for it By:
  - Raising Acceptable Levels (NJ, LA)
  - Lower Distance Criteria (NJ: 100’ to 30’)
- CA-EPA/DTSC: No Quantification
- San Diego DEH: Vertical Profiles

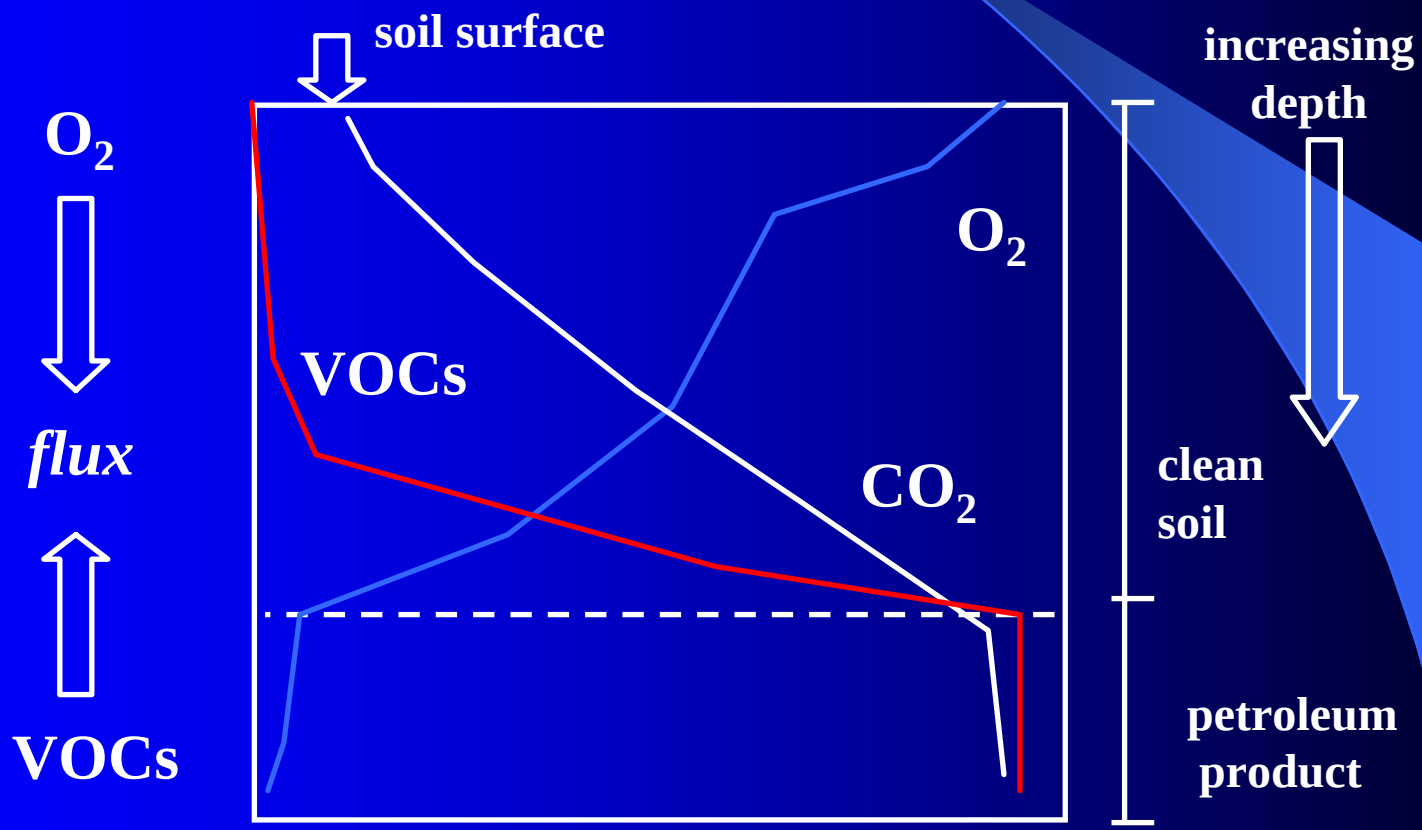
How to Document Bioattenuation

- Vertical Profiles of Soil Gas
- Measure Flux Directly

Soil Gas Measurement

- Pros:
  - Representative of Subsurface Processes
  - Relatively Inexpensive
  - Can Give Real-time Results
  - Regulatory Acceptance
- Cons:
  - Mass Transfer Coefficient Unknown
  - Protocols Still Debated

Theoretical Bio Profile

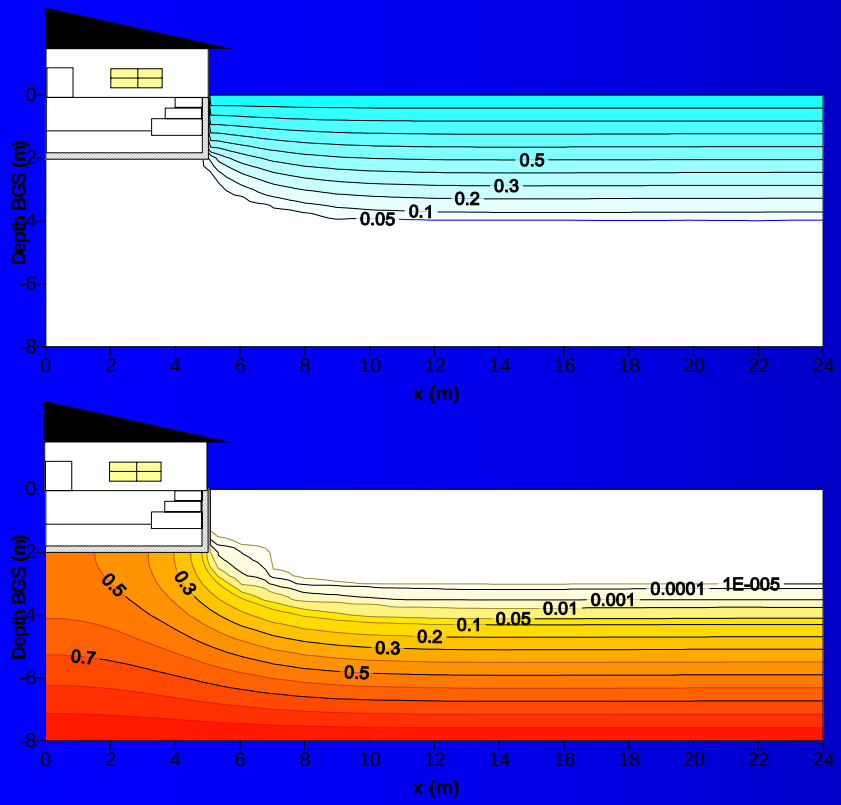


Probe Installation Methods

- Driven Probe/Rod Methods
  - Hand Equipment, Direct-Push
  - Collect sample while probe in ground
- Vapor Mini-Wells/Implants
  - Inexpensive & easy to install/remove
  - Allow repeated sampling
  - Near surface & deep (down auger flights)
  - Can “nest” in same bore hole

Where to Collect Samples

NO OXYGEN BELOW SLAB



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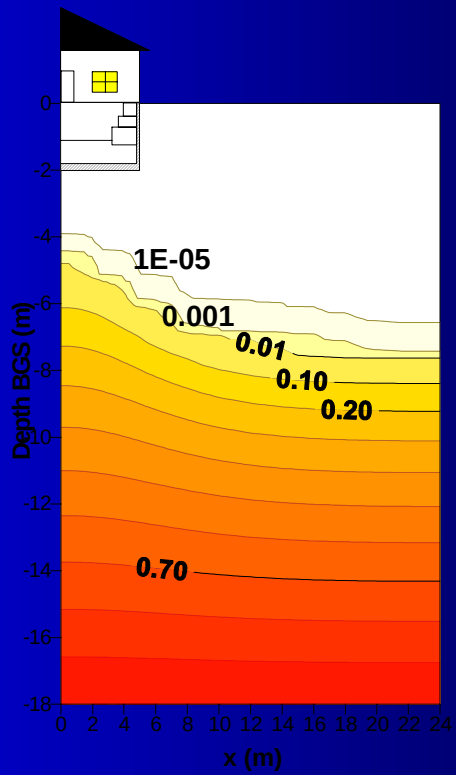
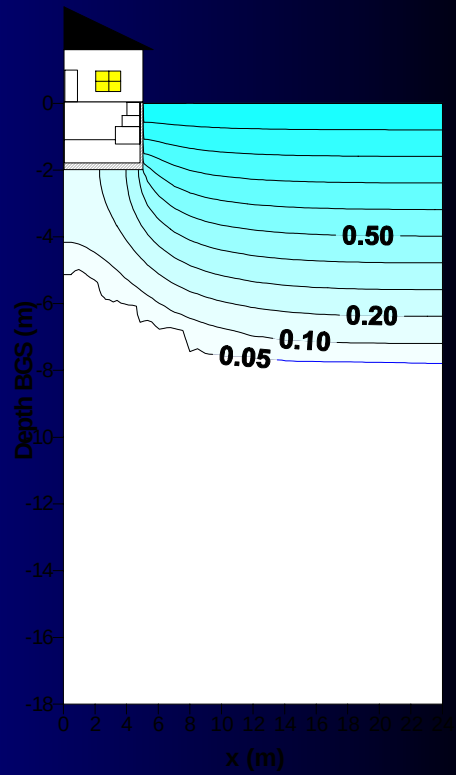




-- from API, 2004

Where to Sample Vertically

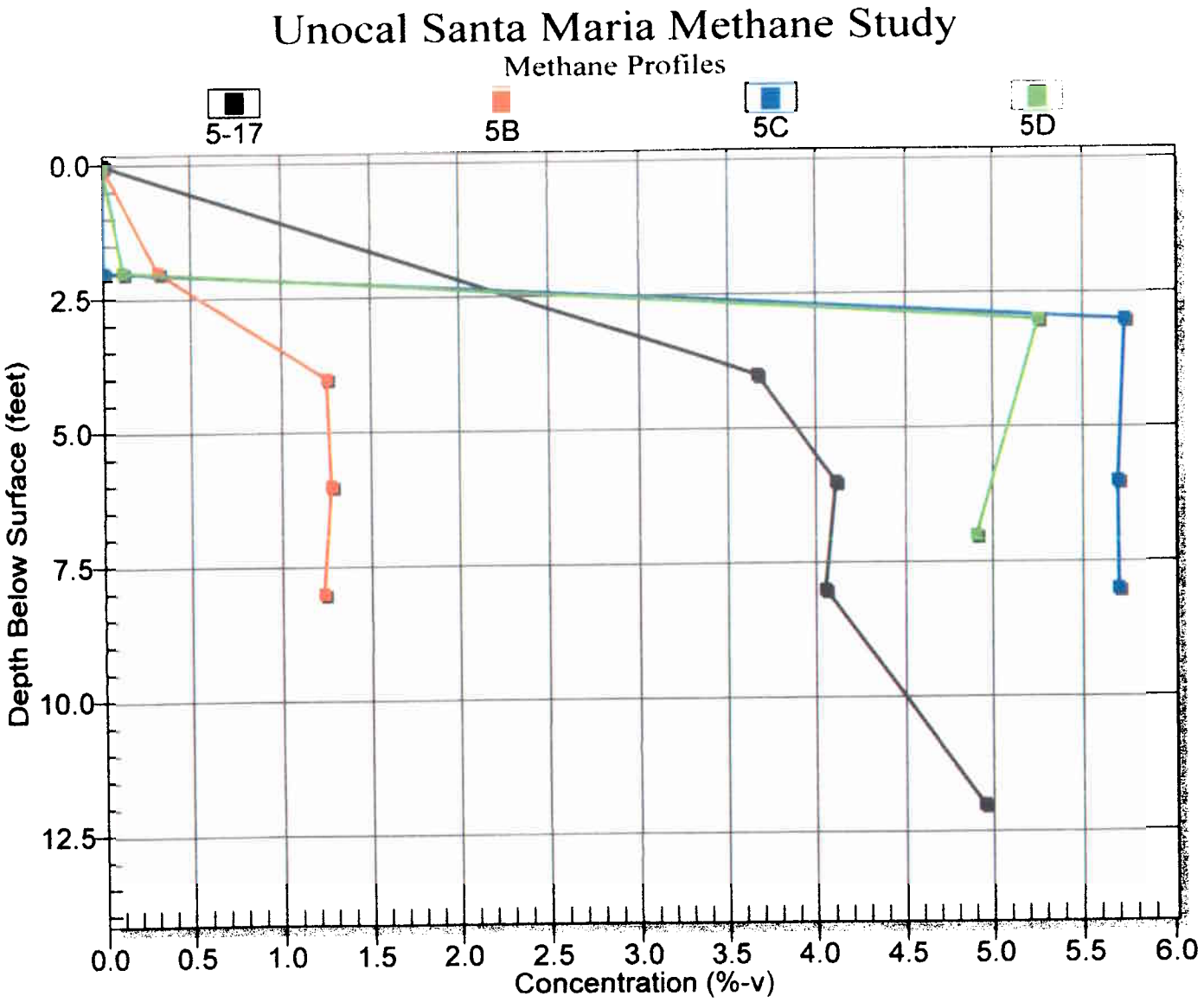
- Need to Find Bioattenuation Zone
  - Use Oxygen as Pathfinder
- Deeper Contamination (>10’):
  - Vertical Profile 5’ to Source (2 to 3 depths)
  - Work Shallower if COC > Fail Level
- Shallower Contamination (<10’)
  - Samples Every 1 to 2 Feet

Where to Sample Spatially

- Source Not Immediately Below:
  - Collect on side towards source
  - Collect on other sides of structure
  - Collect in any preferential pathways
  - Agency restrictions? (NJ vs NY)
- Source Directly Below:
  - Collect around structure before sub-slab
  - Garage?
  - Get decent coverage (no 1-pt anomalies)

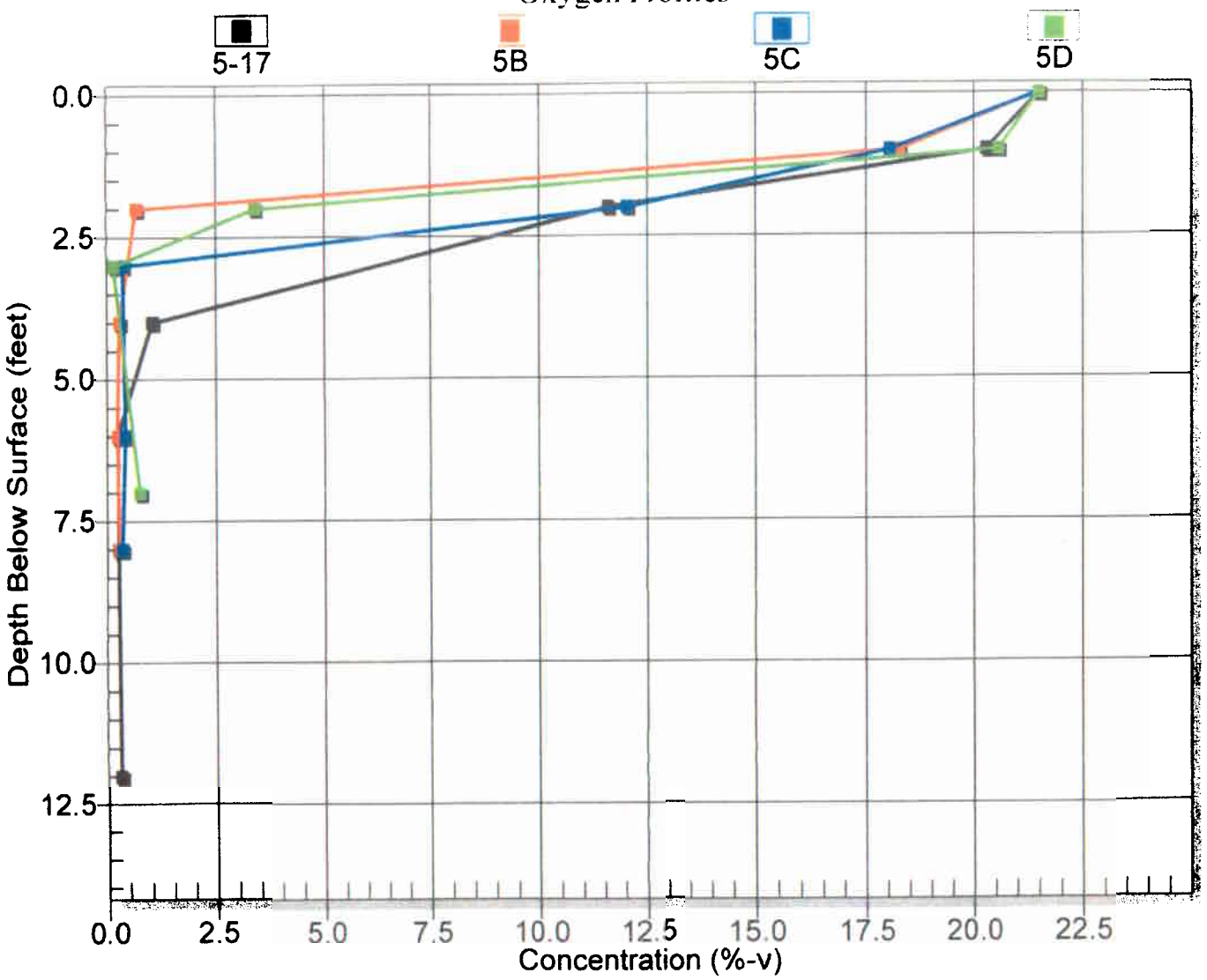
Sub-Slab vs. Near-Slab

- Some Agencies Prefer Sub-slab
  - "Ponding" effect under slab?
  - Balls don't run uphill
- Good Comparison Database Lacking
- Very Intrusive. Attorney time.
- If O_2 High & Source Deep, Near-slab OK
- For Cl-HCs, at GW or mid-way to GW


Unocal Santa Maria Methane Study
Methane Profiles
5-17
5B
5C
5D
0.0
2.5
5.0
7.5
10.0
12.5
Depth Below Surface (feet)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
Concentration (%-v)

Unocal Santa Maria Methane Study

Oxygen Profiles



Soil Gas Key Sampling Issues
(VI Requires More Care & Experience)

- How Much to Collect?
  - Greater the volume, greater the uncertainty
- Containers
  - Tedlars, Summas, Syringes … Don't Chill!
- Temporal Variation/Stability
  - Closer to surface or bldg, greater the effect
- Tracer/Leak Compound
  - Crucial for sub-slab & large sample volumes

Soil Gas Analysis Issues
(TO-15 or 8260 or 8021)

- All Methods Can Give Reliable Results
- Some Agencies Have Preference
- DL & Calibration Range Discriminator:
  - TO-15: DL:1 to 10 ug/m^3 Max: 2,000 ug/m^3
  - 8021: DL: 20 ug/m^3 Max: 500,000 ug/m^3
  - 8260: DL: 100 ug/m^3 Max: 500,000 ug/m^3

SG Levels vs. Fail Levels

- Typical Soil Gas Concentrations
  - Benzene near gasoline soil: >100,000 ug/m3
  - TPH vapor: >1,000,000 ug/m3
  - PCE under dry cleaner: >100,000 ug/m3

- Soil Gas Levels “Failing” VI Criteria
  - Subslab: Benzene: 3 ug/m3, PCE: 4 ug/m3
  - At 5’: Benzene: 150 ug/m3, PCE: 200 ug/m3

TO Method & Hardware Not Designed For This

On-Site/Off-Site Analysis
(8021-8260-TO15 Combo)

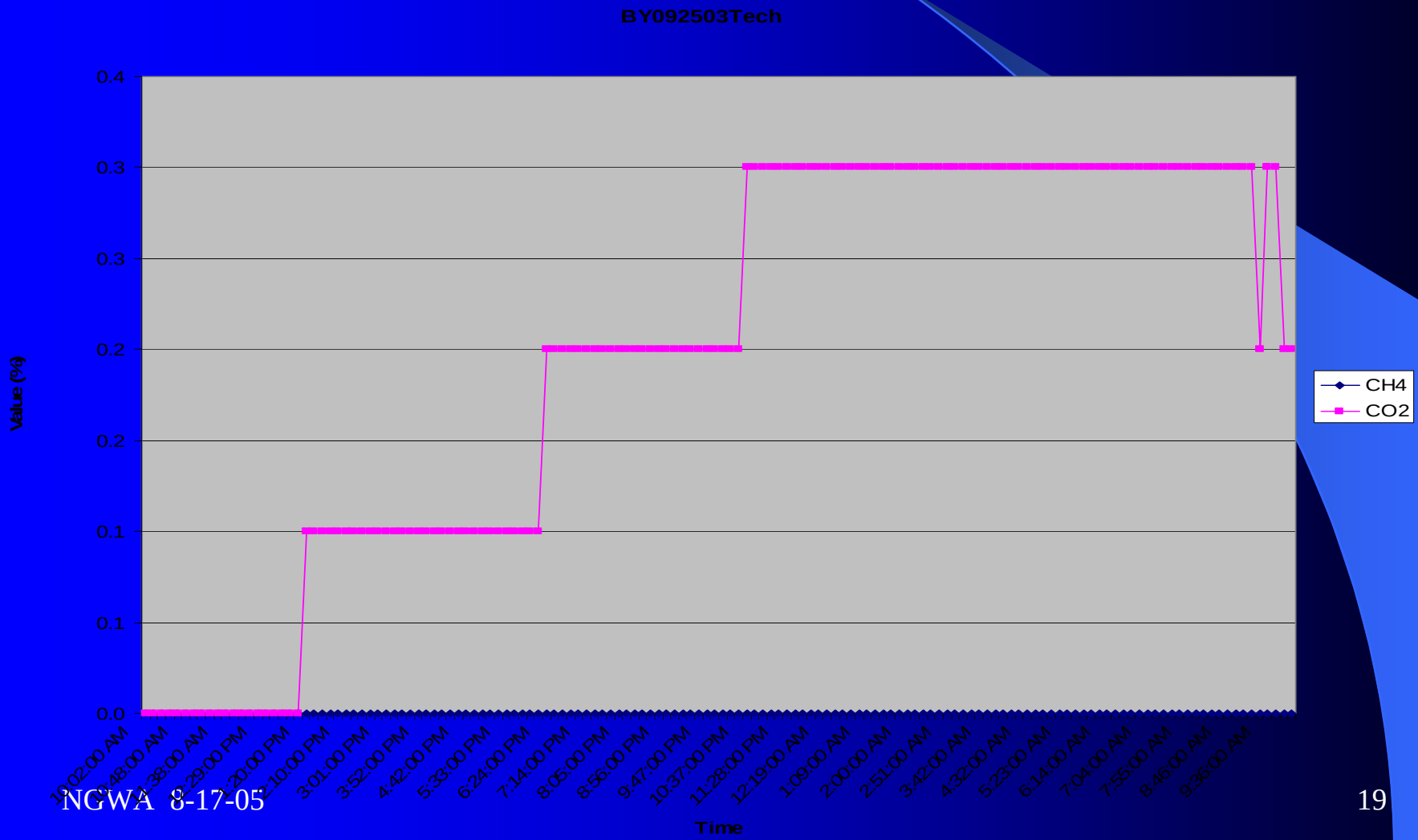
- Measure O_2 to Find Bio Zone
- On-site VOC by 8021 or 8260
  - Real Time Results to Guide Program
  - Use Results as Final for Conc > 100 ug/m3
  - Measure Leak Compound
- Off-site VOC by TO-15
  - For Conc < 100 ug/m3
- Validates Off-site Data
  - Minimizes false positives

Direct Flux Measurement
(Flux Chambers)

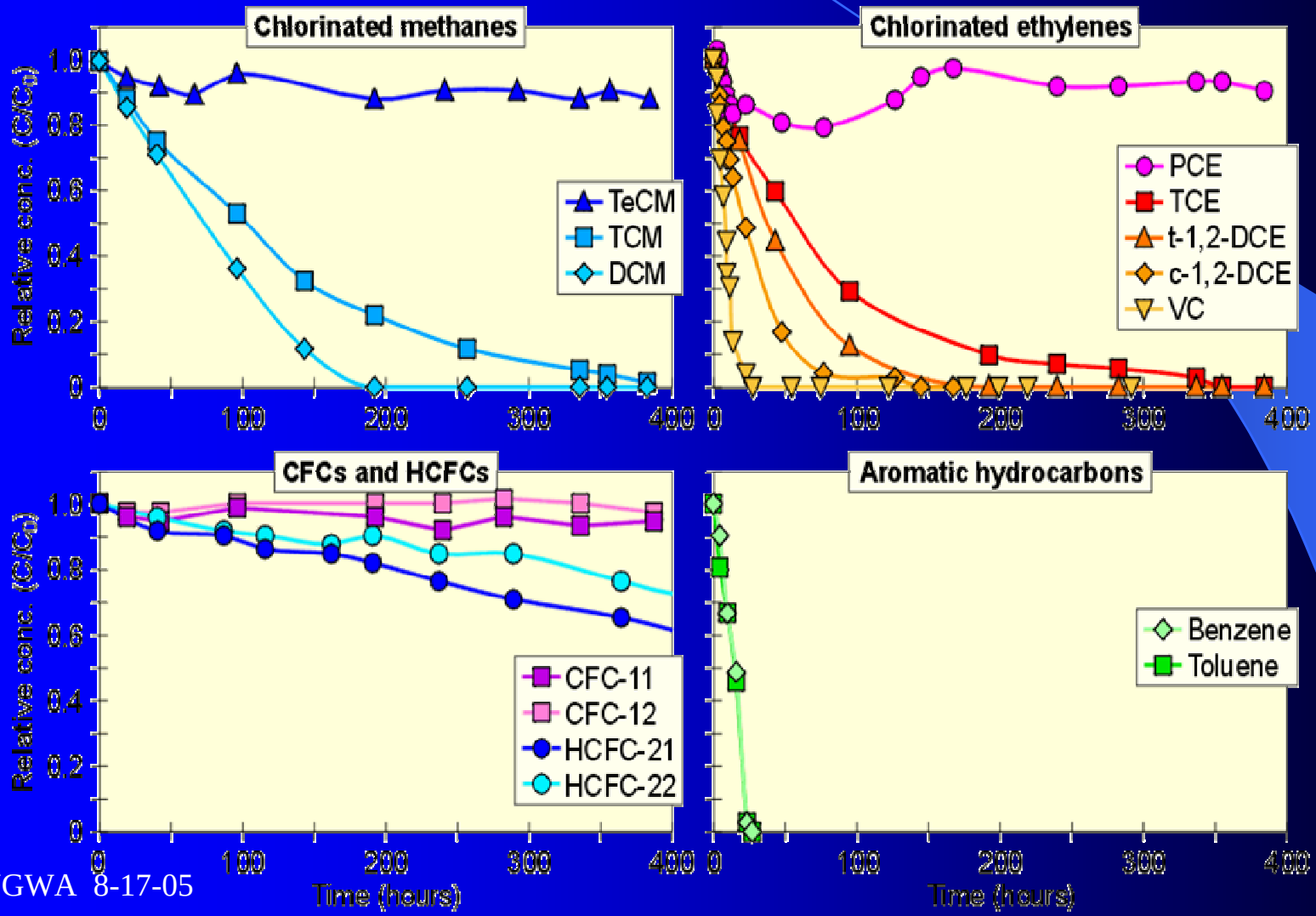
- Pros:
  - Direct Measurement of Intrusion
- Cons:
  - Likely not Applicable Inside Bldgs
  - Protocols Debated
  - Unsophisticated Audience
  - Regulatory Acceptance Limited

Static Flux Chamber

CO2 & Methane in Flux Chamber



FL-State Univ. Data (Jeff Chanton)



Conclusions?

- If Methane at 30% in Soil Gas not Escaping, How Can Benzene at 1 ppbv?
- Studies Suggest Alpha of 1E-5
- Documentation of Aerobic Zone and HC Decrease in Soil Gas May Convince Regulators
- Flux Chambers Second Line of Evidence
- Applicable to Some Cl-Compounds Also?

Existing Documents & Training

- Overview of SV Methods
  - LustLine Part 1 - Active Soil Gas Method, 2002
  - LustLine Part 2 - Flux Chamber Method, 2003
  - LustLine Part 3 - FAQs October, 2004
- Regulatory Guidance
  - CA-EPA Collection Protocols
  - San Diego County Collection/Analytical Protocols

Available at www.HandPmg.com

Existing Documents & Training

- Soil Gas Sampling SOPs
  - Soil Gas Sampling, Sub-slab Sampling, Vapor Monitoring Wells/Implants, Flux Chambers (www.HandPmg.com)
  - EPA-ORD Sub-slab SOP–Draft, Dr. Dom DiGuilio (www.iavi.rti.org/resources)
- Other
  - API Soil Gas Document (www.api.org/bulletins)
  - Vapor Intrusion Web Site: http:iavi.rti.org
  - Robin Davis LustLine Article on Bio, LL#49

Bioattenuation Case History
Step 1: Brief Site Conceptual Model

- Active station – San Diego
- Contaminated soil southern portion
  - Benzene 120 mg/kg, TPH 20,000 mg/kg @15’
- Free product on GW @ 20’ bgs
- Lithology: alluvium over fractured bedrock
- Residence located ~8’ to south
  - Dirt Crawlspace ~ 2’ high
- Does Acute Risk Exist?

Bioattenuation Case History
Step 2: Calculate Risk from Existing Data

- Benzene & Naphthalene the Drivers
- From Groundwater:
  - Use DTSC J-E GW Spreadsheet
  - "GW Fail Level" = 1.7 ug/L for slab
  - Benzene Solubility: 44,000 ug/L
  - Fail By: ~26,000 times (ain't looking good)
- From Soil Data
  - "SG Fail Level" = 0.000084/.001 = 0.084 ug/L
  - Calculated SG Value from Soil: 42,000 ug/L
  - Fail By: 500,000 times (looking worse)

Bioattenuation Case History
Step 3: Collect Additional Data

- Soil Gas Data Best to Collect
  - Benzene Ubiquitous in Ambient & Indoor
  - GW Data Over predicts Risk
  - Bioattenuation Will be Active
  - Try to Stay out of Houses

Bioattenuation Case History
Step 4: Determine SG Fail Levels

- From Default Alpha:
  - Csg (5') = 0.084/0.002 = 42 ug/m3
- From DTSC J-E Spreadsheet:
  - Csg (5') = 95 ug/m3
- If Naphthalene Required:
  - Cumulative Risk Drops Fail Level
  - Fail Level = 95/2 = 47 ug/m3

Bioattenuation Case History
Step 5: Design Soil Gas Program

- At Property Line Towards Residence
- Vertical Profiles to Document Bio:
  - At Worst Case Locations Over Wells & Over Contaminated Soil
  - Along Property Line

Bioattenuation Case History
Step 6: Collect Soil Gas Data

- 5’ Soil Gas Data along Property Line:
  - Benzene 300 to 800 ug/m3
- 100,000 times Below Equilibrium Values
- Indicates Bioattenuation Active
- Collect Vertical Profiles

Bioattenuation Case History
Step 7: Vertical Profiles

- 3 locations at Property Line:
  - 5’: 300 to 800
  - 10’: 300 to 800
  - 15’: 2,000 to 63,000
  - 20’: 140,000 to 430,000
  - 25’: 450,000 to 1,000,000
- Need to go Shallower (3’)
- Values Should Fall Off Towards Structures

Bioattenuation Case History
Step 8: What Next? (Use Other Tools)

- Primary Residences
  - If data fail, propose flux chamber in crawlspace
- What About Other Residences?
  - Any within 100’ of plume or soil in any direction?
- What About Risk to Current Station?
  - Exposure time ~5 times less
  - Sub-slab samples likely better. Radon
  - Measure ventilation rate since much higher
- What About Risk to Customers???
  - Sounds crazy, but it has been asked for