This presentation is an excerpt of the vapor intrusion training that Dr. Hartman has been presenting to Federal & State regulatory agencies, DOD facilities, consulting groups, and stakeholders around the country. As of October 2010, this training has been given to over 30 State Regulatory agencies, including ASTSWMO and the State Coalition of Dry Cleaners. Training has also been given to many PRPs such as the major oil companies, Armed Services, & EPRI.

Lecture notes are at the bottom of each slide so that if played out as a hard-copy, the presentation can be a useful reference document.
Here are some of the proposed changes to the OSWER guidance, due out in 2012.

Meanwhile, OUST is coming out with their own guidance for petroleum hydrocarbons also in 2012.
Based on these studies, a LUFT site is assumed to present no unacceptable risk from vapor intrusion if site conditions indicate that there is:

- *Dissolved* groundwater concentrations below 1000 micrograms per liter (ug/L) for benzene and 10,000 ug/L for TPH and 5’ from receptor.

- Free product is 30 or more from receptor

Under these conditions, it is assumed that natural attenuation is sufficient to mitigate concentrations.

CA State Water Boards are proposing to adopt the exclusion criteria in their new LUFT manual.
In this part of the seminar, we will discuss the primary techniques/tools used to assess the vapor intrusion pathway, including the pros & cons of each.
Some Key VI Assessment Issues

• Experience of the Collector/Consultant
  – Have they done this before?
  – Do they understand RBSLs?
  – Quality/experience of field staff? Sr or Jr?

• Get Enough Data Near/Around/Under

• Legal Perspective
  – How conservative to be or not be?

The most important ingredient for cost effective and efficient VI investigations is the experience of the person/firm doing the collection. Is the collection being done by a firm that has prior experience? Is it a routine part of their services or an occasional part? Do they put experienced people in the field who can think or junior staff who aren’t well versed? This applies to the consultant and their subcontractors.

Soil gas, like soil, is not homogenous in most cases. So you need enough data to give decent coverage near, around, or under the receptor. Simpler collection systems with small volumes are advantageous as there is less to go wrong and enable higher production per day (20+ samples per day). Less expensive analytical methods (8021, 8260) enable more analyses for reasonable cost. Real-time data can be extremely helpful to track soil gas contamination laterally and vertically.

Legal considerations often dictate what additional work needs to be done at what standards.

All of these issues affect the investigation progress.
The most important ingredient for cost effective and efficient VI investigations is the experience of the person/firm doing the collection. Is the collection being done by a firm that has prior experience? Is it a routine part of their services or an occasional part? Do they put experienced people in the field who can think or junior staff who aren’t well versed? This applies to the consultant and their subcontractors.
The Two Most Common Goofs

**Unit Confusion:**
- Assuming ug/L equivalent to ppbv
- Assuming ug/m³ equivalent to ppbv
- Vacuum units: in Hg to inches H₂O

**Screening Levels:**
- Not calculating correct levels
- Comparing data to wrong values

The two biggest goofs being made by vapor intrusion practitioners.
Approach Generalizations

• Indoor Air
  – Always find something
  – Multiple sampling rounds: extra time & $
• Groundwater Data
  – Typically over-predicts risk
• Soil Phase Data
  – Typically not allowed; over-predicts risk
• Soil Gas Data
  – Transfer rate unknown
  – Sub-slab intrusive

Each investigatory approach has pros and cons that must be considered before choosing the one to use at a site.
Indoor Air Sampling Lessons

- Always Collect Ambient Air Sample
- Hardware Issues
  - Blanks
  - Performance – Proper Rate?
  - Fittings Tight? Cross-threaded?
  - Pen/marker Type – Don’t use Sharpies
  - Gauges on cans, not on flow chokes

There are issues that need to be considered when sampling indoor air and when interpreting the data. Sampling issues include the hardware, time period for collection, and things as simple as the type of marker used to label the samples.
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Compounds in Bloonie, a kids toy available in the US.
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More compounds in Bloonie.
Cleaning Your Dishes?
(or Polluting Your House)

Another unsuspecting source of VOCs
## Dawn VOC Analysis Results

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</table>
There are three types of soil gas methods. Active refers to actively withdrawing vapor out of the ground. It gives quantitative values. Passive refers to burying an adsorbent in the ground and letting the vapors passively contact and adsorb onto the collector. It does not give quantitative data and hence can not be used for risk applications, except for screening. Surface flux chambers were discussed previously.

The active method is the one most applicable to risk assessments.
Passive Soil Gas Samplers

Examples of passive collectors.
**Probe Considerations**

- **Tubing Type**
  - Rigid wall tubing ok (nylon, teflon, SS)
  - Flexible tubing not (tygon, hardware store)
- **Probe Tip**
  - Beware metal tips (may have cutting oils)
- **Materials Used to Bury Probes**
  - Sand, cement
- **Equipment Blanks**
  - Need to collect blank through collection system

Some of the issues that need to be considered when installing probes include:

**Tubing Type:** Small diameter tubing offers advantages over large PVC pipe. Flexible tubing tends to leak.

**Probe tip:** Metal tips may have blanks due to the cutting process.

**Equilibration time:** How long to wait, especially if air knives are used to clear holes or larger drill rigs are used?

**Equipment blanks:** need to collect blank through the collection system. Trip blanks not enough.
Soil Gas Sampling Issues

- **Sample Size**
  - Greater the volume, greater the uncertainty
  - Smaller volumes faster & easier to collect

- **Containers**
  - Canisters: More blank potential. Higher cost
  - Tedlars: Good for ~2 days. Easier to collect

- **Flow Rate**
  - Really not imp. But most agencies < 200 ml/min

- **Tracer/Leak Compound**
  - Crucial for sub-slab & larger sample volumes
  - Gases (He, SF6, Propane) & Liquids (IPA)

Lower detection levels require more careful protocols. Important sampling considerations include sample volume, container type, flow rate, and leak testing to ensure valid samples are collected.

Smaller volumes require less complicated sampling systems and minimize the chances for leakage from the surface and desorption off soil. Recent studies have shown no difference in soil gas values regardless of whether small (0.5 L) or large (100 L) volumes are collected.

Sample containers must be inert, clean, and handled properly (no cooling or heat). Canisters have longer holding times, but have the potential for blanks (carry-over from previous samples), cost more, and can be trickier to fill. Tedlar bags are good for ~2 days, are less expensive, and suitable for concentrations of 1 ppbv or higher.

Sample flow rate is of concern to many agencies, but recent data are showing it not to be a factor.

Tracer/leak compounds are generally required to ensure sample integrity because small leaks can create significant effects at such low concentrations. The larger the volume extracted and the more complicated the sampling system, the greater the potential for leaks.
Some Lessons Learned

• Do not mark sample locations with spray paint: toluene

• Watch what you use to seal holes

Loaded with TCE

Loaded with TBA
Deconning or Conning?

Another unsuspecting source of VOCs
### Better Be Sure to Triple Wash!

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<tr>
<th>Analyte</th>
<th>Result</th>
<th>Reporting Limit</th>
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Container Issues

Large vs. mini-canisters

Filling a tedlar bag with syringe

Smaller canisters fill more quickly and are easier to handle. Tedlar bags are simple to use and not prone to as many problems as canisters.
The tackle box on the left shows the required hardware to collect soil gas samples in Summas.

The syringe to the right is the only collection device required for on-site analysis of soil gas.
Leak testing methods using liquid tracers and gaseous tracer compounds.
Soil Gas Sampling for HCs

- Might Need to Sample <5’ bgs
  - If samples >5’ bgs exceed allowable levels
  - How to know? On-site analysis best
  - If not, collect samples anyway
- Always Collect Oxygen Data
- Might Need Soil Phase Data

There are some differences in soil gas sampling for petroleum hydrocarbon VOCs than for chlorinated solvents. If samples at deeper depths exceed allowable values, shallower samples may need to be collected to document the effect of bioattenuation. Oxygen data should always be collected to document presence of the aerobic zone. Soil phase data may be needed to document the presence of a clean soil layer.
Some Final Sampling Issues

- Individual Certified Clean Canisters
  - Not needed if DL > 5 ug/m3
- Residual Vacuum in Canisters
  - Not critical for soil gas samples
- Dedicated Flow Restrictors
  - Not necessary if calibrated orifice restrictors

A few additional sampling considerations.
Common Soil Gas Analyses

• VOCs
  – Soil and Water Methods: 8021, 8260
  – Air Methods: TO-14, TO-15, TO-17

• Hydrocarbons
  – 8260, TO-3, TPH-aliphatics
  – Must check lab to see if they can do

• Oxygen, carbon dioxide
  – ASTM 1945-96

• SVOCs
  – TO-4, TO-10, TO-13

ITRC VI Document, Appendix D. API Table D-1

This slide gives a summary of the most common analytical methods used for soil gas samples. Most of the methods listed here are fixed lab methods.
A variety of portable field analyzers exist for analyzing soil gas samples. For vapor intrusion applications, required detection levels of VOCs are lower than the field analyzers can reach, but they still are useful for screening sites or for sites with high concentrations. These meters give a total concentration only, so they are limited at sites with more than one compound.

Portable hydrocarbon detectors have higher detection limits (~5 ppmv) and do not give compound resolution.

Oxygen, carbon dioxide, and methane can be reliably measured with field meters to required detection levels.
Other Analytical Issues

• 1,3 Butadiene
  – False positive caused by i-butylene
  – Must have lab manually read ion chromatogram
  – Not on DTSC soil gas target list
• Naphthalene
  – 8260, TO-15, TO-17 – DTSC prefers
• SVOCs (sorbent methods)
  – Air Methods: TO-4, TO-10, TO-13
Don’t Forget 8021

• Can get to 1 mg/m³ for TCE, CCl₄, PCE
• Can get to ~25mg/m³ for Benz & Naphthalene
• 5 minute run time for benzene, TCE & PCE
• Cost ~ 1/5 of TO-15

Method 8021 is the forgotten method out there, but it has great sensitivity and offers many advantages over the other analytical methods if only a few target compounds exist.
Supplemental Tools/Data

- Site Specific Alpha Using Radon
  - Factor of 10 to 100. $100/sample
- Indoor Air Ventilation Rate
  - Factor of 2 to 10. <$1,000 per determination.
- Continuous Analyzers
  - Real-time monitoring
- Pressure Measurements
  - Can help interpret indoor air results

Refer to ASTM E2600-08 Table X.1 for summary table

There are some other inexpensive tools/data that can be applied to better evaluate some of the default model parameters and the vapor intrusion pathway. These tools/data have much more influence on the resulting risk than measurement of soil porosity and cost about the same.

Radon can be used to determine a site-specific alpha that may be 10 to 100 times lower than the default alpha allowed.

Tracers can be used to measure the room ventilation rates and may give values 2 to 10 times higher than the default value, especially for commercial sites.

Automated continuous analyzers exist that can provide large amounts of data at low cost with remote monitoring via the internet.

Pressure measurements can be helpful when interpreting indoor air data.
Practical Strategies
(Things to Do)

- Get Enough Data
- Consider Less Expensive Methods (8021, 8260)
- CL-HCs: Vertical Profiles Around Structure
- HCs: Oxygen Profiles Around Structure
- Use Radon for Slab-Specific Alpha
- Measure Ventilation Rate
- Have Experienced Field Team
- Check Your Units!

These are things you want to do/allow to practically and cost effectively assess this risk pathway.
• Overview of SV Methods (www.handpmg.com)
  – LustLine Part 1 - Active Soil Gas Method, 2002
  – LustLine Part 2 - Flux Chamber Method, 2003
  – LustLine Part 3 - FAQs October, 2004
  – LustLine Part 4 – Soil Gas Updates, Sept 2006
  – LustLine – VI For Petroleum Hydrocarbons, Nov 2010

• Robin Davis’ Articles on Bioattenuation:
  – Lustline #61 May 2009
  – LustLine #52 May 2006 (www.neiwpcc.org)

A summary of some existing documents.
Blayne Hartman
Hartman Environmental Geoscience
H&P Mobile Geochemistry
858-925-7206
www.handpmg.com